COOPI

"Drought Consequences Alleviation in Borena Zone - Oromiya Regional State"
Liben Wereda

Terminal report
April 2002-July 2003

Index of contents

Page

I Executive summary

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Project Title:	Drought Consequences Alleviation in Borena Zone
Cooperative Agreement/grant N.:	HDA-G-00-01-00099-00
Country/Regions:	Ethiopia/Oromiya Region
Disaster/Hazard:	Drought
Period covered by this project:	April 01 2002 to July 31, 2003

Summary of the activities

Works

Background: the project was approved by the donor agency on October 1, 2001 and the end was foreseen on September 30, 2002. After the contract was signed, we started the process for the approval of the project with the concerned local counterparts of the Oromo National Regional State. Copies of the project document were given to the Oromiya Disaster Prevention & Preparedness Bureaux (ODPPB) and the Water Bureaux (OWMER). As COOPI had two projects phased out in the year 2001, the regional counterparts wanted to evaluate those projects before signing the contract for the new project. Due to this, the project agreement could be finalized only on April 26, 2002. After this, contacts with the local counterparts were started and the final selection of the intervention sites was made and the organization of the works started. The contacts with the local communities were made too for their involvement in the project as active part of it. The selection of sites was accomplished with the support of social surveys that better clarified the situation expressed by the project proposal and that helped to develop the social activities (Hygienic campaign, water committees constitution and capacity building support).

The Hygienic Campaigns and the organization of the Cost Recovery System were started at the sites were wells were accomplished. The interest showed by the beneficiaries was high considering that the social work started effectively at the time of the selection of the sites. A vehicle mounted with small generator, television, and videotape was used for the hygienic campaign village to village. Topics other than hygiene were taught to people like HIV/AIDS, sanitation practices, environmental protection, etc. Posters, pamphlets, exercise books, and other material were

Figure 1: *Vehicle mounted with audio-visual equipment*

also used for hygienic campaign program. The hygienic program was carried out and accomplished in all the sites of intervention.

The implementation of Negele Water Scheme was affected by the rainy seasons of end 2002 beginning 2003 that were abundant and long. Another problem was the dewatering of the wells in order to improve and clean them. Problems occurred to two submersible pumps used for the dewatering stopped the activity for one month and half. At that time it was decided the refilling of the area through the employment of a great number of workers that minimised the lost of time. At the end of December 2002 most of the area was refilled. Despite the plan for the rehabilitation of the scheme was taken from a proposal of the Water Bureau, some changes were requested during the implementation like the inclusion of 5 wells instead of the planned three and the prolongation of the water line to the treatment plant instead of only to the sand filters.

The water scheme is accomplished. Handing over will be done during the evaluation of the project by the side of the local government.

Figure 2: Dewatering of the wells of Negele Water scheme

The implementation of hand-dug wells: The excavation of eleven hand-dug wells was carried out and accomplished at the end of July 2002. Some, out of these failed because the granite basement was reached before encountering the aquifer or because the water was of bad quality or again because the geo-electrical survey interpretation suggested the presence of water but in reality this reading represented only a sweat layer of sand that affected the survey interpretation. The main problem for the accomplishing of the activities was represented by the long rainy season that affected the area in 2002-2003. From the end of September 2002 to the middle of November 2002 it was impossible to move the workers' teams and all the structures and materials for the hand-dug wells excavations. The truck and cars also were not always able to reach the sites. The same happened during the period from March 2003 to May 2003.

Training and capacity building: the program was finalized sending as per the proposal sending 3 people from the water bureau of Negele to Arba Minch fro a training course about water supply at the beginning of June 2003.

Logistic and equipment: a car was made at disposal of the project since the beginning of the field activities. Geological equipment like the GPS, clinometer, compass, altimeter, water analysis kits, conductivity meter, geophysic equipment for Vertical Electric Sounding Prospections have been purchased and supplied to the project. Field materials, Hygienic Campaign equipment, and Local office equipment and materials in accordance with the project proposal list have been purchased. Hand-pumps have also been purchased together with spare parts kits which have been handed over to the local communities.

Objective#1	Rehabilitation and improvement of management capacity of Negele Town Water Supply

The project foresaw three hand dug wells to be maintained for the supplying of water to Negele town. This water source, together with the existing pond, will be the supply of potable water of the town. At the moment the earth dam is in danger of silting. The basic reasons for the sedimentation are:

- Lack of other sources of water for livestock increase the burden on the earth dam that was originally built for human consumption purpose only. The continuous movement of these animals to the dam creates degradation of vegetation in the upstream side and the soil is exposed to high degree of erosion. This consequently creates silt deposition in the dam.
- Fear of the tension with the rural population denying the access to the pond. Due to this, the local administration is not able to restrain the livestock to be watered at the pond.

The increasing population and the movement of displaced people during droughts around and in Negele town are the other factors that led to plan this project. The project objective is supposed to increase the supply of the water to the town. The planned works for the three HDW and other works (installation of pumping system, laying of water pipeline, construction of pump house) could have been accomplished within the project time schedule but these three wells are interconnected with other two wells. After the discussion held with the counterpart (i.e. Water Resource Office) in the second quarter of the project, it was decided to include the additional wells in the rehabilitation works. This unforeseen activity caused an extension in the completion time.

Before the works began, information about the typology of managements applied in the town regarding the water management, maintenance of the available structures, responsibilities of offices involved and logistic asset of water points in the town were collected on purpose to create a general picture of the present situation. Meetings with all the departments present in Negele town were organized to inform and explain about the general actions that COOPI would have been implementing. The following works have been implemented in full collaboration with the Negele Town authority in order to increase the participation toward the self sustainability of the action.

Rehabilitation of 5 hand dug wells

Management committee

The establishment of the committee for Negele Water Scheme Rehabilitation was suspended and then abandoned because of the "Decentralisation" process that the Ethiopian Govern started about one year ago creating a temporary vacuum of the local bureaus structures as almost nobody was available for taking actions, decisions, and responsibilities.

Finally, the already existing office "*Negele Town Water Supply Service*" that is following the management of Negele town water supply was believed, by all the involved parties, to be able to manage and control the works under the supervision of *Guji Zone Water Department.*

HDW rehabilitation

At the start of the project a survey was organized to confirm the current situation of these hand dug wells and to plan the future activities with the workers and the departments. On mid June 2002 all the technical staffs were involved in a meeting with the purpose to inform them and to give suggestions and alternatives. Some of the material planned was purchased (motor pump and de-watering pump); and two workers started to clean the area from grass and stones. The first dewatering of one of the hand-dug wells started, but some technical problems (lack of petrol in the town and problems with the delivery of the purchased generator for the de-watering pump) forced an interruption of this activity.

The reconstruction of the house for the installation of the motor pump and the topographic survey made to better understand the final pipe line position from this house to the water treatment started in the same period.

Many dewatering attempts were made during the second quarter of the project, but the big quantity of water available in the wells together with some technical problems (like the uninterrupted use of the dewatering pumps that decreases their power) caused a slow down of the activity. Despite the use of four motor pumps at the same time only after 7-8 hours of dewatering the workers were able to enter in the wells and clean them, but after stopping the pumping the level of the water increased rapidly making the efforts very difficult. A trial with the rotation of six motor pumps that worked together with two submersible pumps was made. After 12 hours of dewatering it was impossible to decrease the water level and cleaning was not done.

Only at the end of September 2002 when the water department gave to us a high capacity pump to us it was possible to clean other two linear meters but without reaching the bottom of the wells yet. The situation of the wells was showed to the departments in Negele town whom only fear was to loose even the smallest amount of water out of the wells refusing the abandoning of two of the five wells. This was based on debatable suggestions because, as above explained, the amount of water withdrawn from the wells was so high not to justify their explanations.

At the end of December 2002, the dewatering activities in Negele Water Scheme were stopped because of the high quantity of water that affected the area during the rain season together with the breaking of the two submersible pumps involved in this activity. The idea was to undertake the dewatering using the pump that should have been purchased to pump the water to the treatment plant. The technical characteristic of this pump was discussed with the Negele Water Department and the final agreement was for the order of a motor pump able to provide to the Water Treatment Scheme of Negele town a quantity of water estimated in 5l/s (18 m^3 per hour covering one third of the town water demand) at 70 metre of head.

In the mean time the masonry works were already started and continued along the implementation of the activates as well as the reclaiming of the area that was divided in two phases: the first one was represented by the use of the available soil obtained in the intervention area by the cutting and stuffing of hills and walls coming from the topography of the area; sand was mixed together with the obtained soil to prevent the cracks during the hot seasons and all these materials were compacted by human power. The second phase was represented by the transport of material by truck from a quarry with variegated clay available near Negele town. After the reclaiming work was accomplished, the construction of drainage channels around the area to better drain the rain waters far from the wells started and it was accomplished by June 2003.

Figure 3: masonry work of one of the wells and, in background, reclaiming activities

In brief the works carried out are below listed:

- Excavation and construction of drainage channel at the down stream of the wells that drains the water downstream avoiding clogging in the area is completed,
- Clearing, plastering and well head constructions as well as the finishing works of the five wells are completed;
- The construction of the basement for the surface pump is completed. The submersible pump is lowered in the main well.
- The submersible pump was connected to the main electric line with 400 m of underground cable.

Rehabilitation of the water line

The rehabilitation of the water line started removing the old connection between the main hand-dug well and the old buster house. Then, the mapping of the new pipeline trough the help of a level instrument was done.

After a detailed discussion made with the Municipality office responsible of Negele Special District the problem of the existing sugarcane farms along the planned track of the pipeline and the request of money by the farmers owning them, was solved by paying some money to compensate the lost production.

This line was traced with the help of rope out the breadth of this line calculated in two meter of soil that must remain clean from cultivations and others for a distance estimated of 1,044 m. Excavation of trench and laying of pipeline were completed by the end of June 2003. Pipe laying work was not completed in the scheduled time because of the change on the pipeline design. In fact, at the beginning it was planned to connect the pipeline to the filtration system, which is the nearest point. Since the water from the new wells has no turbidity problems, the water department officials advised to change the inlet of the pipeline into the treatment plant. This required more pipes to be laid and then additional 120 meters of trench were excavated for the additional length of the pipeline.

Construction of pumping equipment shelter

The re-construction of the booster pump's shelter started with the old pump removal and handing it over to the Water Department. Problems were related to the accessibility to the site that is into the compound of the Ethiopian Red Cross. The missing presence of the responsible of the Red Cross created disagreement with the guard that did not permit to the workers to enter and deposit materials in the work area. Only at the end of August 2002, it was possible to solve these problems but with a considerable delay in the activities.

Figure 4: Booster pump after the rehabilitation

The rehabilitation of the water cistern near the booster house was possible because the conditions of this structure were still good and needed only some fittings, plastering and rendering of the internal and external walls.

The remaining works, like final paint of the internal part and pavement work surrounding the house of maintenance of the reservoir and construction of the Motor Pump (booster pump) house were accomplished in July 2003.

Training of the Borena Zone Water Supply

Based on the project proposal design, it was agreed the training to be held at Arba Minch Water Technology Institute. The type of course and credit hours planned are:

- Electricity 70 hrs;
- Metal workshop 50hrs;
- Engine 60 hrs;
- Pumps operation and maintenance 80 hrs;
- Well and Borehole rehabilitation;
- Generators and Pumps 15 hrs;
- Water quality analysis 45 hrs.

Two people from the water department of Negele Borena started the training at Arba Minch on June 23, 2003.

Objective #2 Increased safe water for drought affected rural communities

Social sector

General

Special attention was given to the social activities related to the construction of hand dug wells, from site selection to handing over of the scheme. At the beginning, a survey was conducted for understanding the socio-economical situation of the area.

An agreement with the communities was signed to help the organization in the works; many beneficiaries participated in the construction when the necessary human power was needed; at the same time their presence during these activities was a good chance to transfer to them and sense of awareness.

The overall social activities, besides the constitution of Village Water Committees, accomplished were:

- Assessments conducted in all sites of intervention concerning availability and need of water, farming situation and basic problems prevailing in the area;
- Rural water committee established. The water committee is composed by: chairman, secretary, cashier, 2 members, and 2 water technicians. Women were added to increase their participation in the implementation of the project and to increase their role in management of the scheme after handing over;
- Awareness was created by repeatedly raising the idea of cost recovery system and hygienic aspects for the committees constituted.

Beside the accomplished social activities, repeated meetings with the communities to remind the water committees about the harmonious flow of cost recovery system for which continuation of money collection from the community for the efficient utilisation and management of the scheme. The activity was accomplished in all the intervention sites.

The communities were mostly showing a great interest and motivation concerning the implementation of the project.

Training of VWMC

All the selected sites were covered by the work of social agents that applied the selection principles of the "Water Committee Managing Manual" of the Oromiya National Regional State Bureau (1998) to select the Water Committee members and the people that will implement the hygienic sensitization program. At the same time it was modified the approach of selection in agreement with the community and tried to base these selections with suggests of chairmen and communities.

Figure 5: VWMC training session

It is possible to summarize the main points discussed during the village meetings in:

- General information about rural water committee;
- Duties and responsibilities of rural water committee;
- Criteria to be members;
- Rights and obligations of the committee;
- Relation between rural water committee and different organizations.

The constitution of the Village Water Member Committee for the selected hand dug wells is accomplished. After the members' selection and their first "training" about mansions and responsibilities, the social agents monitored them during the construction of the wells.

Planning and teaching about Cost Recovery System was accomplished and the community answered in a positive way. Most of the VMWC started immediately the collection of money fixing an amount of cash to be collected.

The Cost Recovery System that COOPI supported was improved with the implementation of a survey organised in the area in collaboration with the local counterparts, to analyse what are the changes compared to the time the organization started the operation in the area.

The training was given for a total of 84 members, out of which 24 were operators and the remaining are management committees. The training was given in collaboration with Guji Zone Water Resource Office, i.e. all the trainers were from this office.

The main topics covered in the training: (for all the committee members)

- Concept of community participation and its advantage;
- Water use, sanitation, health and hygienic education;
- General concept of cost coverage;
- Financial management;
- Guidelines for management of rural water supply system.

Beside this, pump operators were trained about:

- Operation and maintenance of water scheme at village level;
- Assembling and disassembling of hand pump.

Hygienic campaign

After their constitution of the water committees, the organization's Social Agents started the Hygienic Campaigns using the "PHAST" method ("Participatory Hygienic and Sanitation

Transformation" – WHO & UNDP – World Bank Water and Sanitation Program 1997) teaching how the community should participate and manage (hygienically and ethically) to the use of water in general and also in the specific use of the hand dug well. Video Tapes about Water Sanitation and General participation in the Water Management were shown at each place selected for one day each trough the help of a vehicle mounted with TV, the VCR powered by a generator. The program was supported by the Social Agents. The participation was high (around 250-300 people for each site) and the preliminary discussion at the end of the day gave good suggestions about diseases and general awareness. The hygienic campaign was carried out as a routine activity in all sites. The campaign was carried out in two rounds. In both rounds many children and women got the chance of participating. This is because the campaign was held also near to schools which allowed students to take the advantage to participate.

Disinfecting of the completed wells was the other activity accomplished by this sector. Majority of the completed wells were treated by bleach that has 5% Cl_2.

Cost coverage

The term cost coverage implies: a system of opening bank accounts for the sustainability of realised hand dug wells. The organization facilitated the community to start the system and pursuing it attaining positive results. Despite this, opening the account for any of the committee was not an easy task due to the change in the process by the local water department responsible. Agreement was reached with the community of the intervention areas where water schemes were already accomplished. According to this agreement the constituted VWMC should have collected money from the beneficiaries to be saved in a Bank account as starting balance that will help for rehabilitation and maintenance of the scheme in the future.

For each community the level of contribution was according to their living standard.

12 (including Mugayo) VWMC were constituted in twelve project areas.

Construction Hand-Dug Wells

11 HDW have been completed. These are: Buradera, Dolcha, Bokola, Arda Bururi, Haro, T. Dhelan, Mucho, Sirba and Nurahumba, Wofe, and Mede.

Details of activities on each site are reported below.

Buradera HDW for Solar Pumping System

A geophysical survey was done and a good amount of water in the area was detected. At the depth of 11.50 meters the water was more than 200 litres per night. A thick plastic waterproofing rock obstructed the underground water circulation. Anyhow, during the excavation, when this was crossed, the water rapidly came up.

At the end of September 2002 the construction of the rings started and all the material for the construction was delivered to the site. The excavation stopped at a depth of 15m after that the reinforced concrete rings were installed.

Figure 6: *Buradera – water works for the solar system*

Delay of implementation occurred because of the rainy season that did not allow the delivery to the workers of materials and ring moulds on the site.

All activities are accomplished. Details of works are below listed:

- Construction and set up of 16 reinforced concrete rings;
- Construction of the reservoir's support and installation of the reservoir;
- Construction of solar panels' support and setting solar panels;
- Installation of both hand-pump and solar driven submersible pump;
- Laying of the pipeline from the well to the reservoir as well as fixing the necessary fittings for the public fountain;
- Fencing and associated finishing work such as painting;
- Installation of the solar system;
- Installation of a solar pump;
- Recovery test and disinfection of the well.

The scheme was temporarily handed over to the community that is using it.

Wofe HDW for Solar Pumping System:

This is the second site planned for installation of solar system. Although already in the program, the specific location of the well was selected in the last quarter of the project.

This activity should have been the result of an agreement between COOPI and the Ethiopian Red Cross Organization.

The existing out of order construction present in the site, was accomplished by Westphalia Red Cross on May 1994. After the receiving of an "aid request letter" from this community the two organizations decided to divide the work and to develop the existing water point as here below described.

Figure 7: *Wofe – water works for the solar system*

COOPI: should have installed a solar water system following the normal construction's procedures (water tank support for a 10 m^3 capacity fibre glass tank, solar drive house, solar panel installation, water point distribution, and fencing).

The Ethiopian Red Cross should have rehabilitated the existing hand-dug well and install a hand pump (back-up pumping system) and constructed the connection for the submersible pump of the solar system.

The agreement was not brought to a successful conclusion so that COOPI had to start the works alone selecting a new site.

The well was excavated to a total depth of about 11m. The yield was less than the expected one and therefore it was not suitable for water exploitation with a solar pumping system. For this reason, the well construction design changed into two wells which were then connected by an underground drainage trench. A second well of 7m and a trench 14 m long and 7m depth were excavated (*Figure 7*).

The drainage trench has been packed with filter gravel up to 3m below the ground level. The remaining 4 m were backfilled with compacted selected clay to avoid infiltration of the surface water and likely contamination of the well's water.

Details off works are the same listed for Buradera above.

The scheme was temporarily handed over to the community that is using it.

Figure 8: Wofe Water scheme after accomplishment

Tola Dhalan

After a first survey of one week that covered all Hardot kebele, the point for the excavation of the hand dug well was located. A team of social agents covered, with the help of a questionnaire, the area of intervention with the purpose to collect all the possible available information. Through these we decided, in collaboration with beneficiaries, to select the place where the well was excavated. The contribution of beneficiaries was represented by the opening of a path to reach the site and, sometimes, in the digging helps.

Figure 9: Tola Dhalan HDW

The particular hard condition of the area did not permit the accomplishing of the geophysical survey. The geological situation showed a not clear picture of the area but, trough the help of the population, it was possible to get a general idea about the place where to dig. Unfortunately, the presence of a boulder at 6.2 meters depth forced the selection of a new place 1.5m near to the first one. At 4.5m depth a very good amount of water was found; the excavation continued up to 7.3m. A pumping test was done and a yield of 0.7 l/s was calculated.

In the first quarter 2002 the works were accomplished. The scheme was temporarily handed over to the community that is using it.

Mucho

The works started in the quarter July-September 2002. During that period, the excavation was terminated after having reached the depth of 14.85m and set up of the rings was accomplished. During the excavation a suspended water table was met that did not assure the planned amount of water expected by the results of the geophysical survey. Then it was decided to keep on digging and to reach the fractured basement.

At that time the water disappeared and another decision to reach the fresh basement (representing the supporting surface of the aquifer) was taken.

Figure 10: Mucho HDW

At the end of the excavation the total amount of recharging water inside the well in the firsts 24 hours was low ($7m^3$), but after 48 hours the quantity increased ($15m^3$ approximately) and after 3 days a very high quantity (around $33m^3$) was met. At that time it was decided to organise the excavation of drainage holes (80 cm of diameter and 1.5 meters long) to increase the drainage surface at the level of the static water level, in agreement with the water situation of the area. These allowed a better drainage of the aquifer and a faster recharging.

The works are accomplished. The scheme was temporarily handed over to the community that is using it.

Sirba

During the third quarter of the project, the location of the hand dug well for this site was done and the works started and accomplished with the construction of the slab and the installation of the hand pump.

The construction of the fence (the delay was a consequences of the unavailability of material on Negele market) was accomplished in the fourth quarter. The quantity of water is high for a HDW working with a hand-pump (according to the pumping test around 0.7 litres per second).

Figure 11:

The geological survey was done together with a stratigraphic survey which information will be collected in the final geological report. The total depth reached is 5.4m. Before this, one well was excavated at 3.2m but failed (see Well accomplishment report)

The works are accomplished. The scheme was temporarily handed over to the community that is using it.

Bitata Bura

The particular geological situation (granitic province) makes this area difficult for the excavation of hand-dug wells. Many failed attempts made in the past by other organizations confirmed these problems. The project's geologist made different geophysical surveys to understand and correlate the final results to locate the well in the area. It was the intention of the organization to excavate this well because of the strong request from the community related to the big problems this is facing during the dry seasons. The excavation started but after 4 meter the hard basement rock was encountered and works suspended. The organization will undertake a deeper study in order to satisfy the people's request in the future within other projects.

Dolcha

The construction started the first week of December 2002, upon receiving of a letter from the community asking help for the construction of a hand-dug well because of the lack of water. Thus, a team was organised for the excavation and the works started. The excavation was accomplished at the depth of 8.5 meters after the hard removal of the fractured biotitic gneiss rocks. The masonry works then started and the works were accomplished on January 2003. The scheme was temporarily handed over to the community that is using it.

Figure 12: Dolcha HDW during construction

Bokola

The excavation of the HDW started in coincidence of Dolcha works. The estimated depth of the well was around 4.5 meters with the aquifer estimated to be found in fractured gneissic rocks. The excavation was accomplished at 5.2m mid of December 2002 and the last days of the same month the mould for ring's construction was transported to the site. The reinforced concrete rings were constructed and installed. The overall works were accomplished on January 2003. A temporary handing over of the scheme was done to the community which is benefiting from it.

Figure 13: Bokola HDW

Jidola

This hand dug well started mid of December 2002 and at the end of the same month 3.5 meter were reached with a good amount of water. The planned depth of this well was around 7-8 meters in agreement with the geo-electric survey that estimates the depth of the massive basement around there. Unfortunately, being the aquifer within a not good media, the water table was very much

influenced by the seasons with great draw down during the dry season. The total excavation depth was of 7m. In the same area the community asked us to dig another well 8-9 km far from this one where there was high population density without access to water. A social and geophysical survey on December 2002 were made but in the mean time we came to know that a planned borehole in the same area was not communicated to us by the Jidola Administration and forced us to abandon the planned activity. We came to know then later that the borehole was abandoned.

Harro

The well is located 6 km from Negele town and was selected after the request of support by the community. In the area there is a borehole that is strictly reserved to the military camp use. This is a highly populated area of displaced people that constitutes a big community around Negele town and that has no access to water points. In fact the nearest Kebele called Wofe with a large amount of water is reserved only to its community and the borehole only for the encampment. The only possibility for this community to fetch water is from traditional *"Ella"* that during the dry season are dry. At the end of December 2002 the depth of 4.5 meters was reached and the water table encountered. The estimated depth of excavation was around 7.8 meter. The fresh basement was encountered just below the water table thus mining the chance for the water to be exploited. The site was moved and the excavation started. The new well is already finished at the depth of 4.7m and temporarily handed over to the community which is benefiting from it.

Figure 14:

Arda Bururi

Arda Bururi was selected and started during the last quarter of the project. The depth of the well is 7.3m and the following were the accomplished works:

- Excavation of well to a depth of 8 meter,
- Production and installation of reinforced concrete rings in to the well,
- Construction of superstructure,
- Hand pump installation,
- Fencing
- Recovery test and disinfecting the well was also accomplished,
- Temporary handing over to the community.

Figure 15:

The community is using the scheme.

Mugayo

The selection of the site was made in order to satisfy request of the nearby communities and to exploit the great potential of the aquifer of the area. The aquifers are in loosen sands very difficult to excavate because of flowing of sand when wet. Excavation work reached 8m before collapsing. Then the workers started clearing the well by removing the collapsed material but the work was not easy because the water flow together with the sand was too fast. The work was therefore left for sometimes until new equipment was purchased. Due to lack of budget under this project, COOPI guaranteed the finishing of the work through other funds within the end of August 2003. The equipment was purchased and the remaining of the works finished through funds from other donors. The scheme is these days (September 2003) working and people are benefiting of it.

Nurahumba

This site was selected during the last quarter and activities have started in this quarter. After excavating seven meter, the well collapsed and we shifted the excavation to another position in the same area. In the second position, it was observed that the area had good potentials for ground water development. The excavation continued up to the basement without problem of caving. For avoiding collapses, workers were assigned to pump continuously the water from the well. The depth of the well is 7.5 m. Construction of rings and lowering them inside the well continued. Superstructure works were also accomplished and the hand pump installed. A temporary handing over of the scheme was done to the community which is benefiting from it.

Figure 16:

Mede

This was a new site selected during the last quarter of the project based on the hydrogeological survey and the community interest. Excavation work started and stopped after digging a depth of 5.85m. The excavation work was stopped temporarily in order to avoid the collapse before lowering the concrete rings. However, because of the sandy nature of the aquifer, the shaft was caving and, since it was not possible to go deeper, we abandoned it. Like Nurahumba site, another nearby position was selected and excavation reached around 8.1 m. The set up of the concrete rings is almost accomplished and a mason for the construction of the superstructure and the finishing works has already been assigned.

Figure 17: Mede Water Scheme

The general situation of all hand dug wells implemented in this project is resumed in the following table.

No.	Name of site	Scheme	Situation	Well depth	Distance from Negele (Km)	Remark
1	Buradera	SP[1]	Completed	15	20	
2	Wofe	SP	Completed	11+7+trench	3	
3	Tula Dhalan 1	-	Abandoned	6.2	20	X
4	Tula Dhalan 2	HP[2]	Completed	7.3	20	
5	Mucho	HP	Completed	14.85	45	
6	Sirba1	HP	Abandoned	3.2	38	
6	Sirba2	HP	Completed	5.4	38	
7	Bitata Bura	-	Abandoned	4		X
8	Dolcha	HP	Completed	8.5	67	
9	Bokola	HP	Completed	5.2	47	
10	Jidola	-	Abandoned	7		X
11	Harro 1	-	Abandoned	4.5	6	The well is accomplished with funds from other donors
12	Harro 2	HP	Completed	4.7	6	
13	Arda Bururi	HP	Completed	8	9	
14	Mugayo	-	-	8	35	The well is accomplished with funds from other donors
15	Nurahumba 1	-	Collapsed	7	30	
16	Nurahumba 2	HP	Completed	7.5	30	
17	Mede 1	-	Collapsed	5.85	38	The first well collapsed at 5 meter
18	Mede	HP	Completed	8.1	38	

[1] Solar pump
[2] Hand pump

OBJECTIVES

Objective#1: Rehabilitation and improvement of management capacity of Negele Town Water Supply

Objective#2: Increased safe water for drought affected rural communities

INDICATORS

Objective#1:	Total in the program	Achieved	Remarks
Number of hand dug wells rehabilitated	3	5	2 other wells added in the plan
Metres of water line rehabilitated	1044	1266	Completed
Number of people getting access to water	7,500	7,500	
Handing over certificate	1	0	The handing over will be done after the regional authorities will evaluate the project

Objective#2	Total in the program	Achieved up to now	Remarks
Number of hand-dug wells constructed	9	11	
Number of water committees constituted	9	12	Mugayo training was already undertaken
Number of beneficiaries	13,000	15,000	Newly accomplished HDW not yet handed over
Number of people trained:			
VWC	63	77	
HDW Operators	14	18	
Solar pump operators	4	4	

RESOURCES

Budget:	USD 336,182.00	Expended this period (month of July 2003):	USD 7,757
Cumulative expenditures to date:	USD 336,562.00	Balance:	USD (380)

II Program Overview

A Project goal and objectives

Goal: Improved potable water for drought affected community in Negele Woreda.

Objectives:

- **Objective#1: Rehabilitation and improvement of management capacity of Negele Town Water Supply**
- **Objective#2: Increased safe water for drought affected rural communities**

B Profile of the targeted population and the critical needs identified in the proposal

Semi-nomadic pastoralism remains the dominant livelihood system defining the rural Borena economy, although some communities are slowly looking at agro-pastoralism in order to diversify livelihood options and avoid complete dependence on livestock production. Borena pastoral communities have, in recent years, come across fairly calamitous livestock losses, declining forage availability for their animals, poor terms of trade, shrinking water sources, crop failures, shortages of food supplies, and political insecurity worsened by conflict with neighbours over access to resources. As a result, Borena households and communities had to find ways to cope with chronic household livelihood insecurity.

Livelihood strategies continue to be limited to a few central activities, dominated by livestock production, used for consumption and income-earning purposes. Almost all Borena households trade in livestock or livestock products. Household daily activities are mainly focused on herding, watering, and milking animals. Women must balance particularly onerous daily labour requirements. Few rural children attend schools, partly because access to primary schools is poor, partly to assist in the labour needs.

Borena society is very co-operative; however, access to scarce resources has become more limited in recent years, rendering food and resource sharing more difficult. Borena society, which is relatively equitable within the context of Ethiopia, has become more unequal during the last two decades, largely as a result of four major droughts which have depleted livestock reserves and left about 40% of the total households characterized by chronic food insecure.

Social services, including health facilities, schools, markets, agricultural and veterinary services, and credit institutions, are inaccessible, very limited, or too distant from the villages “ollas” to be of functional use to households. However, one of the major constraints to livestock production and ultimately household livelihood security is the availability of water for human and animal consumption. These constraints to household livelihood security have compelled every rural Borena household to adapt to a combination of several coping strategies, including:

- Reduced food consumption;
- Significant changes in the diet;
- Increased consumption of wild food;
- Livestock distress sales;
- Reliance on food aid;
- Short-term loans;
- Assistance from olla members and relatives;
- Unusual patterns of migration;
- Livestock redistribution; and
- Increased attempts at crop production.

Population characteristics

Negele district is estimated to be inhabited by 116,729 people (according to the 1994 census). Among 116,729 people approximately 89,057 are the rural inhabitants and 27,672 the urban ones. The data refers to 1994 population census for Oromiya Region. The major ethnic groups living in the area are Oromo (Guji, Arsi, and Borena) and Somali (Gerry, and Marihan). The Somali groups are mainly concentrated around the town of Negele.

C Geographic location of all major activities

OBJECTIVE#1: The five hand-dug wells that this project was rehabilitating are located in the Kebele 01 of Negele town. These are more than one kilometre far from the Water Treatment Building, place that must be connected with our intervention area. The GPS position of these hand dug wells is, included in a range of 30 meters around the GPS point N5º19.405, E39º34.383.

OBJECTIVE#2:

No.	Type of scheme	Name of site	Geographical position		Elevation
			North	East	
1	Solar Pump	Buradera	05^0 12' 48.4"	39^0 33' 09.8"	1231
2		Wofe	05^0 20' 32.2"	39^0 35' 51.9"	1531
3	Hand Pump	Tula Dhelan	$05^0$15'29.1",	$39^0$26'27.6"	1279
4		Mucho	05^0 36' 25.9"	39^0 22' 19.5"	1584
5		Sirba	05^0 32' 22.0"	39^0 25' 34.5"	1490
6		Dolcha	05^0 40' 10.7"	39^0 19' 09.5"	1589
7		Bokola	05^0 27' 23.8"	39^0 20' 09.0"	1393
8		Harro	05^0 20' 57.2"	39^0 34' 46.9"	1482
9		Arda Bururi	05^0 24' 21.0"	39^0 35' 06.9"	1385
10		Nura Humba	05^0 27' 55.9"	39^0 24' 49.0"	1510
11		Mede	05°24'20.4"	39°23'55.4"	1394

III Program performance

A Program performance, vis-à-vis the program objective

1) Progress, Period, and cumulative achievements referred to the revised plan of action are here below listed.

Activities	Unit	Project plan Qty	Quarter Plan Qty	Quarter Accomplishment Qty	Cumulative Plan Qty	Cumulative Accomplishment Qty	Description/ remarks
Equipment							
Geolog/hydrog.	gross	1	1	1	1	1	All equipment supplied
For hygienic campaign	gross	1	-	-	1	1	All equipment supplied
Hand pump	set	7	-	-	7	9	All equipment supplied
Solar pump	set	2	-	-	2	2	All equipment supplied
For HDW construction	gross	1	-	-	1	1	All equipment supplied
Various (field material)	gross	1	-	-	1	1	All equipment supplied
Works							
Hygienic campaign	months	12	-	-	12	15	Accomplished
Protected HDW for HP	n	7	-	-	7	9	Accomplished
Protected HDW for SP	n	2	-	-	2	2	Accomplished
Rehabilitation of Negele WS scheme	n	1	-	-	1	1	Accomplished
Transport							
4WD rented	months	13	1	1	13	15	
Truck rented	months	-	3	3	14	14	
Motorcycle	n	2	-	-	2	2	
Other items							
Local office equipment/mat.	gross	1	0	0	1	1	
Evaluation	n	1	0	0	1	1	Accomplished
Training							
Training water supply	committees	9	-	-	9	11	
Computer training	workers	0	0	0	0	0	
Capacity building WS of Negele	committees	1	0	0	1	1	

2) Why targets were not met and how the impact has been, or will be addressed

All targets were met but not on time because.

B Successful stories

The successful story refers to an interview made to an elder of the community of Nura Humba. Among the beneficiary communities, Nura Humba is the one that COOPI provided with two hand-dug wells which are 8 Kms apart. For the past decades this community was suffering from lack of potable water and used to fetch water from depression from which livestock also used to drink water.

One of the residents of this Village, Obo Hussein Abiya, said, while reminding the situation of the previous years:

"I can't say we were like cattle rather I would say we were cattle during the past years because We used to drink water from where cattle usually drink from and infect it by their mouths that always carry infected parasites from grasses and leaves while grazing. Now we are even psychologically treated and I am sure no one will take his child or no one will go to health centers to look for treatment for diseases related to water. Now we feel we became human beings thanks to the work of COOPI we can now fetch the water safely and easily, and also without the fear that our children fall down in to the well and die".

Obo Hussein finalized saying:

"Help also our neighbours that are still suffering from lack of water and that are also suffering from diseases related to water and improve their human being condition."

C Unforeseen circumstances and their effects on the program performance

The following were the circumstances which affected the implementation of the project.

- Delay in signing the implementation contract with the Oromo Regional State;
- Prolonged rainy seasons of late 2002 (October to November extended also to December) and early 2003 (March to May) which obstructed the logistic;
- Decentralization process which created vacuum of responsibilities into the technical and administrative local structures;
- Partnership agreement for Wofe with the Ethiopian Red Cross Society failed;

The common effect was a delay in the implementation process. Due to delay the organization asked a three-month period extension.

IV Resource Use/Expenditures

Category	Unit	Months	Amount	Revised Budget OFDA	Total costs until 30-06-03	Total costs 31-07-03	Total costs until 31-07-03	Budget Balance
Expatriate personnel				**38,000**	**38,000**	**0**	**38,000**	**0**
Project manager	1	8	4,000	36,000	36,000	0	36,000	0
Country representative	1	2	4,500	2,000	2,000	0	2,000	0
Local personnel				**41,400**	**42,100**	**0**	**42,100**	**-700**
Project Manager assistant	1	12	500	6,000	4,536	0	4,536	1,464
Accountant	1	12	300	3,600	3,442	0	3,442	158
Secretary/store keeper	1	12	150	1,800	1,429	0	1,429	371
Mechanic	1	12	200	2,400	2,800	0	2,800	-400
Drivers	2	12	150	3,600	5,628	0	5,628	-2,028
Watchman	4	12	80	3,840	5,122	0	5,122	-1,282
Geologist	1	12	400	4,800	4,206	0	4,206	594
Social agent	2	12	300	7,200	5,732	0	5,732	1,468
Building engeener	1	12	300	3,600	2,340	0	2,340	1,260
Water technician	1	12	300	3,600	4,192	0	4,192	-592
Cleaner	1	12	80	960	2,673	0	2,673	-1,713
Travel				**1,975**	**1,444**	**0**	**1,444**	**531**
International travel	1		1,000	975	975	0	975	0
Local travel	24		100	1,000	469	0	469	531
Equipment				**89,509**	**87,486**	**0**	**87,486**	**2,023**
Geolog/hydrog. Survey equipment			7,187	8,300	8,824	0	8,824	-524
For hygienic campaign			4,566	3,750	3,250	0	3,250	500
Hand Pump	7		1,325	8,356	8,443	0	8,443	-87
Solar Pump	2		10,000	17,400	17,281	0	17,281	119
10m3 Fibre-glass tank	2		5,000	5,815	5,815	0	5,815	0
Well material (see list in section VII.1)			14,783	8,300	7,965	0	7,965	335
Various (field material see list in section VII.1)			6,875	6,956	7,008	0	7,008	-52
Submersible pump and pipes			15,000	13,000	13,148	0	13,148	-148
Back up motor pump			3,000	7,239	7,292	0	7,292	-53
Spare part for motor pump			2,000	2,000	183	0	183	1,817
Spare part set hand pump	10		50	493	493	0	493	0
Spare Solar drive	4		1,500	7,900	7,783	0	7,783	117
Works				**82,955**	**79,238**	**3,480**	**82,718**	**237**
Carry out hygienic campaign	9		125	1,125	1,175	0	1,175	-50
HDW for hand pump	7		5,500	38,500	38,191	0	38,191	309
HDW for solar pump*	2		7,900	15,800	12,447	3,480	15,927	-127
Rehabilitation of Negele Water scheme*	1		17,700	17,700	17,655	0	17,655	45
Capacity building water supply			6,000	6,000	6,022		6,022	-22
Training water supply			3,830	3,830	3,748	0	3,748	82
Other				**71,843**	**70,260**	**4,000**	**74,260**	**-2,418**
Car 4x4 Rental and Operational Costs	1	12	1,900	22,800	22,800	0	22,800	0
Truck rented	1	2	4,500	15,000	14,992	0	14,992	8
Motorcycle purchased	2		3,000	4,169	4,174	0	4,174	-5
Vehicles operation and maintenance			9,760	11,900	13,027	0	13,027	-1,127
Office Rental	2	12	376	6,474	6,684	0	6,684	-210
Local office equipment/material			8,000	7,500	8,583	0	8,583	-1,083
Evaluation	1		4,000	4,000	0	4,000	4,000	0
TOTAL DIRECT				**325,682**	**318,528**	**7,480**	**326,008**	**-326**
Audit				**500**	**277**	**277**	**554**	**-54**
Indirect Cost				**10,000**	**10,000**	**0**	**10,000**	**0**
TOTAL REQUEST				**336,182**	**328,805**	**7,757**	**336,562**	**-380**

* This items have been increased in budget according to the explanation given in our letter ref. n. 393/2003 in which we have been asking for a budget reallocation of 5,500USD from the Audit budget line to the works (HDW for solar pump and Rehabilitation of Negele Water Scheme)

V Plan of work for the next quarter

Not Available.

Annexes

Annex 1: Social Sector General Report

SOCIAL SECTOR GENERAL REPORT

Contents

INTRODUCTION

The project, Drought consequences alleviation project in Borena Zone Liben Woreda has planned to rehabilitate Negele water supply system and rehabilitation and construction of 12 (Twelve) hand dug wells in rural villages in order to alleviate the water shortage of the area, to have an improved access to safe water and to contribute its role in supplying more and appropriate water supply system.

During the implementation of its planed activities social sector plays its own roles. This report holds all social activities carried out during the period of implementing the project.

SURVEY/ASSESMENT

The involvement of the intended beneficiaries is crucial for the success of development activities. To achieve this goal the social section made social investigation or survey prior to the physical activities.

The basic aim of the survey was

- To identify users interest in the program;
- To determine the communities willing and whishes;
- To determine the like and dislike of intended beneficiaries especially towards our planned goal; and
- To identify total number of population and beneficiaries in the implementation areas.

During these survey questioners was drawn by the social section. The questioner contains basic questions which are essential for implementing the project. Main participants during the survey were ‘Kebele’ executive committee members (Chairman vice chairman Secretary), community elder’s, women and other beneficiaries.

According to the survey made in the intervention areas spatial and temporary rainfall distribution pattern and amount are highly prevalent with droughts being a repeated phenomenon greatly affecting food security and lively hood of the population. Permanent water source are scarce for both animals and human being. Due to the influence of rainfall distribution in the area the farmer's practice of rain fed agriculture is discouraging, i.e. the production is very small.

Other infrastructures like school, roads, animal and human health centers are not available in most of the areas.

Names of the implementation areas, the number of house hold of the over all population and the beneficiaries are listed below;

Ser No	Name of peasant association (P.A)/Kebele	Site of the intervention	Total population in the P.A	No. of beneficiaries of the scheme (in house hold).
1	BURADDHERA	Bura dhera	2000	200
2	HARDOT			
3	SIRBA	Gefersa	976	290
4	MUCHO	Dendema	3250	140
5	KOBADI	Haro	7000	150
6	AREDABURURI	Arda Bururi		
7	DOLCHA	Dolcha		
8	BOKOLA	Har lekole	2400	110
9	NUREHUMBA	Nura humba		100
10	NURHUMBA	Medade		
11	WOFE	Wofe		980

Table 1 Names of the implementation areas, population size and beneficiaries No. of the schemes

NB No of the population and beneficiaries' number is according to the information gathered from the executive committee's of the community.

RURAL WATER MANAGEMENT COMMITTEE

Organization of rural water management committee was one of the activities performed, which was carried out during the project period. Rural water management committee was organized in all the project site before the beginning of the physical works. The water committees were constituted in agreement with the communities. In that all the beneficiary community had came together and oriented about the need to elect water management committee and then, the community elected the members democratically. Generally 11 rural water management committees were set up. In all the project sites the water committee was composed of seven (7) members, out of this 2 to 3 were women. The constituted rural water management committee contains a total of seventy seven (77) members.

The establishment of rural water management committee was carried out according to the Guide line of Oromia region "Management of rural water supply system." The established rural water management committee consists;

- Chair man
- Secretary
- Casher
- Two technician and
- Two members

In most of the organized rural water management committee responsibilities related to money was given to the women members, because women have a capacity to control and manage money properly and they are trustful by the community.

RURAL WATER MANAGEMENT COMMITTEE TRAINING

In order to make rural water management committee members aware and well understand their duties and responsibilities, giving training to them was important. Taking this point in to consideration, training was arranged for the rural water management committee members of all the project sites. The training was held in Negele town by expertise from Guji Zone water resource office. In the training water technician were also included. The trainers from Guji Zone water resource office consists of: one community promotion expert, one operation and maintenance expert, and one sanitation expert in collaboration with social section staff members of COOPI.

Rural water management committees under training

The training was aimed:

- To improve the proper utilization of the water scheme
- To improve users hygienic practice
- To enhance sustainability of the rural water supply scheme
- To strengthen management of water resource at community level
- To introduce management guide line of rural water supply
- To give them some ideas about financial management and book keeping
- To enable them to operate and maintain their water scheme.

In general the training was intended equipping the participant with knowledge needed to incorporate in managing their water scheme properly.

The training was given by using different teaching methods that are:

- Class room teaching on the out lined topics
- Visual observation at filed
- Video shows and
- Group discussions and other possible efforts applied to clarify and to make easy and understandable the training for the participant.

All the organized rural water management committees and the technicians were attended the training. The rural water technicians were attending both the management and the technical part of the training.

In general 77(seventy seven) rural water management committee members educated the management aspect of rural water scheme: out of these additional training was given to 18 trainees about operation and maintenance of hand pump and 4 trainees about operation of solar pump. The training was conducted for five consecutive days. Three days for the management part and the remaining two days for technical aspects.

The training enables the trainees to manage their water scheme and to carry out ordinary maintenance of the hand pump and to operate the solar drive.

SANITATION CAMPAIGN

The other activity which had been carried out by the social sector was hygienic campaign. The campaign targeted to all the beneficiaries mainly the women through the meeting.

The primary objective of the campaign was to create awareness to the beneficiaries about the advantage of using potable water sources. Generally during the campaign the community gained the following;

- Advantage of using clear water
- Disadvantage of unsafe water
- Disease caused by water such as water borne disease, water washed disease, water related disease.
- Proper management of water schemes and other related topics was addressed to the beneficiaries in different days.

Beneficiary community while receiving hiegienic & sanitation education

The methodology at the campaign was participatory base. The communities fully involved in the discussion. Different teaching aids like video tape, pamphlet and posters were used. Using these different teaching aids made the participant to understand easily and to have a good willing and interest to the campaign.

WELL OR WATER TREATMENT

During the excavation and superstructure works procedures that were accomplished in the realization of a hand dug well pollution was suspected due to different reasons like construction materials falling in to the well, contact made with diggers foot prints during excavation, different foliages falling into the well before the closing of it. For this reason the wells were disinfected using common disinfectant, Ghion Bleach disinfectant that contains 5% of chlorine.

Water or well treatment had been made in most of the constructed wells at the end of the construction and prior to use of the water by the beneficiaries. The amount of the Ghion bleach disinfectant used in all the wells varies according to the volume of water in the wells.

To determine the amount of disinfectant used, calculation was made according to the Phsico chemical testing (ref. Water training manual prepared by Oromia water mineral and energy resource development bureau laboratory service water quality team).

After treating the wells with the disinfectant the water pumped with the installed hand pump in order to disinfect the pumping equipment as well as to mix the well water and the disinfectant. The wells were allowed to stand for 3 to 5 days to allow chlorine to dissipate and then after the water was drained out or pumped from the well by using

robin and submersible pump until the emerging supply showed only about 0.1PPM residual chlorine

Because of the situation of the wells after completion water treatment had not been done in few areas. Due to the stress of water in some of the areas the community started using the scheme just after completion and the late accomplishment of the scheme in wofe locality was some of the reasons.

Now a day all the wells become safe potable water scheme and the beneficiaries are utilizing properly.

Table 1.3 Amount of disinfectant used during treatment of each well

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Site of the wells	Volume of water in the well in Liter	Amount of Ghion bleach disinfectant used in Liter.
Mucho	9300	9.3
Dolcha	6000	6.0
Bochola	2500	2.5
Aredhabururi	1930	1.9
Nurhunba	8800	8.8
Medhaday	5200	5.2
Haro	5720	5.7
Hardot	4200	4.2

COST RECOVERY

To make the constructed water schemes sustainable, establishment of cost recovery system is advisable. During the project time of Drought consequences alleviation project in Borena Zone, attention was also given to this activity.

In most of our intervention areas the beneficiaries agreed on this idea and the system was established. The communities agreed to set up the system at the beginning by collecting money from each beneficiary. All of the community members in the project sites initially promised different amount of money for starting up the system. The amount of money promised by the communities depends on their living condition, beneficiaries' number and their interest.

For most of our intervention areas, the proportion of cost recovery was very small, as a result of the wide spread of poverty in the areas. Although most of the localities had happened such problem some of them deposited more than 500 (five hundred) Ethiopian birr to their water scheme. This shows that the interest of the beneficiaries to wards the system.

The system was started in all the project sites. The water management committees deposited their money in the bank in the existing (already opened) current account **"NEGELE RURAL WATER SUPPLY SCHEME"** which was opened by the zonal water department.

Names of villages where water schemes were constructed and their performance in collecting and depositing money are listed below.

Ser.No	Peasant association/Kebele	Locality	Type of scheme	Cash deposited Et.birr.
1	BURADHERA	Buradhera	Solar pump	0.00
2	MUCHO	Dhenadhem	Hand pump	950.00
3	SIRBA	Gefersa	Hand pump	500.00
4	HARDOT		Hand pump	215.00
5	AREDABURURI		Hand pump	0.00
6	KOBADI/HARO	Haro	Hand pump	300.00
7	DOLCHA		Hand pump	300.00
8	BOCHOLA		Hand pump	100.00
9	NURHUMBA	Nurhumba	Hand pump	260.00
10	NURHUMBA	Medhaday	Hand pump	150.00
11	WOFE	Wofe	Solar pump	354.00
12				

N.B. Buradhera and Arda Bururi localities are on going to put the collected money in bank account.

ADITIONAL ACTIVITIES

During the implementation of the project social section made different activities for the achievement of the project. Especially in the promotion activities the section plays its own role. Activities like

- Awareness creation towards the developmental activities
- Mobilization and motivation of the communities

To construct and rehabilitate roads
To bring available materials from the surrounding
To keep construction materials properly
To fence the water scheme additionally by local materials
To participate on the sanitation campaign were some of the activities

Generally during the implementation of the project the communities' interest, willingness and participation in different activities help us to perform and to complete the intended activities properly.

For successful implementation of the project it is advisable to work with the community hand in hand.

CONCLUSION AND RECOMMENDATION

Generally, working with the people to the people to full fill their basic need and interest in various developmental activities have a good acceptance by the beneficiaries.

During implementing our activities the participation of the beneficiaries to wards the planned activities is really very admirable. Keeping working with the communities hand in hand in the feature is recommendable.

It was understood that the effort being made mainly by our organization to improve water availability for human consumption is not enough with respect to the severity of the problem in the district. To alleviate the problem additional more efforts are needed on this sector to enhance potable water consumption of the communities.

The establishment of rural water management committee and equipping the members with management and technician skill will help the constructed water schemes to give service properly to the beneficiaries. Also the establishment of cost recovery system to all water schemes will play a great role for maintenance and proper management of the schemes. To strength the system farther more follow up is needed.

Due to the weak traditional hygienic habits of the beneficiaries measurable impact seems to be rather difficult to achieve through this single sanitation campaign farther more strong and routine effort is needed to get additional effective results.

Annex 2: Social Survey for all Sites

A. Introduction

Basic data assessment was made in Borena zone Liben Woreda in all intervention areas where the USAID-OFDA project "Drought consequence alleviation in Borena Zone Liben Woreda" was planed to be implemented. The objective of the assessment is to know the general situation of the area in order to identify social and economical facts of the communities of the areas considered for excavation of hand dug wells through implementation of the project 'drought consequence alleviation in Liben Woreda'.

In this assessment it was tried to detect and describe the situation of the communities especially on the situation where the sources of water for human and animal consumption is considered as the crucial factor.

The information was gathered by the discussions hold on at all the villages with the presence of the PA executive committee members, members of the community and women's. The survey for all the project sites is included in this report.

B. Mucho

General information

Mucho is one of the PA found in Liben Woreda of Borena Zone. The main ethnic group in the area is "Guji". The livelihood of the community is mainly based on rearing of animals and production of crop. According to the information taken from the community during the survey, around 3,250 people live in the area and the population settlement is very scattered.

Mucho PA has six localities.

1. Dhendhama

1. Darara
2. Kukelilo
3. Gambel
4. Gicha
5. _____

N.B Dhendhama: - is the place where a hand dug well scheme was constructed by COOPI.

Total No. of HH	Main economical activities	Animal health service	Market for crop and Livestock	Source of water for human and Livestock	Technical assistance received
270	Livestock rearing & Crop production	No	No	Traditional Ela and Pond	No

Table B.1 General situations

Water for human Consumption

The community has basic problem concerning water. They fetch water for human and livestock consumption from traditional had dug well "ELA". During dry season the traditional water source dries up, due to this they are obliged to look for water from the neighbouring PA's like 'Wadara' and 'Zenebaba' which are 25 and 15 km far away from the PA respectively.

Source	Average distance	Turbidity	Daily consumption per HH	Disease prevalence water born	Potable water scheme
HDW	3-5 km	Turbid	60-80 Lit	Not reported	HDW & pond

Table B.2 water for human consumption

Water management

In the area Water management committee was not well known before because, there is no water scheme constructed by governmental or non governmental organization. But at the time of this survey, there is a new hand dug well constructed by "SCF". This organization formed the water management committee. The newly formed management committee is not yet started to perform their duty and responsibility.

Livestock

Animal husbandry is the main farming activity in the area. The farmers have owned caw, goat and camel (not as such common).

They lively hood of the community basically based on the product and sells of animals. During the long dry season due to lack of water the livestock used to shift to neighbour areas where water is available all the year, these are 'Wadara' and 'Zenbaba'.

Source	Average distance	Daily consumption per animal	Disease prevalence (water born)	Water scheme
Pond and Ela	15 km	It is well known	Not reported	Pond, Ela

Table B.3 water for livestock

Veterinarian clinic is not available in the area even the community did not get any technical assistance concerning treatment for their animals except when some times the governmental organization gives vaccination for their livestock during disease break out.

Availability of animal post	Availability of animal health technicians	Main livestock disease	Way of treating livestock
No	None	Different kinds of diseases	Vaccination service

Table B 4 Live stock conditions

Farming system

The farming activity in the area is not as such considerable. The community practice rain feed agriculture; One house hole on average cultivates 0.5-1

Hectare of land. As the result of the recurrent drought and the nature of the soil the production do not exceed from their consumption. The rugged nature of the land and the type of soil of the area made the area not good for crop production. Some farmers use fertilizer like urea and DAP in order to improve their production

Average land holding per HH	Main crops produced	Method of cultivation	Purpose of crop production	Source of water for crop production	Main crop production hindrance
0.5-1 hector	Maize & Wheat	Manual	For consumption	Rain	Drought and pest

Table B.5 farming situations

Storage

In this area some of them have traditional wood type storage. This type of store is not safe from the damage of crop pests. The community does not have means to manage store problem.

Storage type	Main storage pest	Crop pest	Traditional remedy
Traditional wood type	Termites	Termites	Not reported

Table B.6 Storage situations

C. Sirba

General information

Sirba is found North West of Negele approximately 40 km far from Negele. Guji is the main ethnic group in the area. They are agro pastoralist in which they are depending on crop production and animal husbandry. According to the communities information 976 people live in the area.

Sirba has five localities

2. Germed
3. Holo

4. Gafarsa

5. Wolan
6. Sokora

N.B Gafarsa is our intervention locality.

Total No of HH	Main economical activities	Animal health service	Market access for crop and Livestock	Source of water for human and Livestock	Technical assistance received
290	Livestock rearing & crop production	No	None	Ela	None

Table C.1 general information

Water for human consumption

The main sources of water for human consumption are traditional well (Ela) and Pond. These water sources are poor in their sanitation and consequently

are not reliable for human consumption. The traditional wells found in the area predispose the community for water born and water related diseases.

In Sirba there is no water scheme development so far by government and non governmental organization our intervention is the first for this community.

Water management

Due to absent of developed water scheme in the area water management is not known. It needs closed follow up to teach and aware the community about water management committee.

Source	Average distance	Turbidity	Daily consumption per HH	Disease prevalence water born	Potable water scheme
Ela	In the area	turbid	40-60 Lit	Malaria Water related disease Amoeba	HDW

Table C.2 Water for human consumption

Livestock

The main livestock found in the area are cow, goat, camel and donkey. They have pasture in the surrounding. Rarely during sever dry season the animal face shortage of pasture and water at this time the community leave the area to Genale and Wadera areas to look for water and pasture.

Source	Average distance	Daily consumption per animal	Disease prevalence (water born)	Water scheme
Pond and Ela		100-1200 Lit	Aba senga	Ela

Table C.3 water for livestock

Animal health post is not available in the locality but there is a veterinary clinic at Harekelo which was constructed by COOPI

Availability of animal post	Availability of animal health technicians	Main livestock disease	Way of livestock treatment
No	None		By Vet-scout

Table C.4 livestock situations

Farming system

The farmers in Sirba PA practice crop production by rain fed agriculture. Their techniques are poor and the crops are mostly damaged by drought; one house hold can have 0.5 – 1 hectare of land for cultivation.

Average land holding per HH	Main crop production	Method of cultivation	Purpose of crop production	Source of water for crop production	Main crop production hindrance
0.5-1 hector	Maize, Barely, & Wheat	Manual	For consumption	Rain	Drought and pest

Table C.5 farming situations

They received seed from different governmental and non-governmental organizations.

Storage

Here also there is no as such reliable storage system. People use traditional storage made from woods that are not durable and there are high losses of grains due to the poor storage system.

Storage type	Main storage pest	Crop pest	Traditional remedy
Traditional wood type	Termites	Stock borer	Smoking the storage grain Appling of ash

Table C 6 Storage situations

D.Hardot

General information

Hardot is found 24 km west of Negele. The Lively hood of the community is agro pastoralist that based on stock raising and crop production. The village has lack of infrastructures like school and health post both for animals and humane being. According to the information get from the communities around 1500 people are leaving in the area. Their settlement is scattered. Most of the residents are Guji ethnic group.

Total No of People	*Main economical activities*	*Animal health service*	*Market access for crop and Livestock*	*Source of water for human and Livestock*	*Technical assistance received*
1500	Rearing of animal & Crop production	No	Negele	Ela	None

Table D.1 General Situation

Water for human consumption

Their main source of water is hand dug well and traditional “Ela”. There is a hand dug well constricted by COOPI and it is only used by some localities. Other localities in the same PA that are living far from the HDW were obliged to use water from “Ela” (Traditional well), which was not safe for human consumption

Source of water	*Average distance*	*Turbidity*	*Daily consumption per HH*	*Disease prevalence (water borne)*	*Possible water scheme*
HDW Ela	3 to 4 km	HDW_not turbid Ela-turbid	40 lit	Not reported	HDW

Table D.2 Water for human

Water management

They have a water management committee in a place where constructed water scheme is available. It consists of chairperson, secretary and technician, which control the water activity in the area such as to collect

money from the beneficiaries and managing the scheme properly are the basic. The constituted management committee need follow up to strength the system farther more.

Farming system

The farmer carry out crop production by rain fed agriculture. Drought and unfavourable environmental condition in the area affect their crop production.

The farmer practise traditional agricultural activates.

Average land holding per H.H	*Main crop production*	*Method of cultivated*	*Purport of crop production*	*Source of water for crop production*	*Main crop production hindrance*
1 to 2	-Maize Wheat	Traditional	For house hold consumption For sell	Rain	Drought

Table D.3 farming situations

Livestock

This community rear different kinds of animals like cows and shoats. The animals get a good pasture during rainy season but during dry season they face shortage of pasture. This problem forced the herder to shift their live stoke to the surrounding area.

Source	*Average distance*	*Daily consumption per animal*	*Disease prevalence (water borne)*	*Water schemes*
Traditional hand dug well “Ela”	It take 30 minutes		Not reported	No water schemes for animals

Table D.4 water for Livestock

In this locality there is no veterinary clinic, even there is no technician to treats their animals. The herders treat the animals by them selves by purchasing drugs from nearby town, Negele. If the situation is severe they used to take the will go to Negele. The community have welling to have animal health post

Availability of animal post	*Availability of animal health technician*	*Main live stock disease*	*Way of treating live stock*
Not available	Not available	Not reported	by the herders (By purchasing drug)

Table D.5 Live stock conditions

Storage

The storage situation is the same of the other PAs. It is traditional store mad from wood and grass. Pests and rodents mostly affect the stored food

Storage type	*Main storage pest*	*Crop pest*	*Traditional remedy*
Traditional wood type	Rodent		Smoking grain storage

Table D.6 Storage situations

E. Dolcha

General Information

Dolcha is a locality which is found in Guduba bururi peasant association in the North West of Negele. It is approximately 64 km far from Negele.

Guji is the main ethnic group in the area. The community is agro pastoralist in which they are mainly depending on crop production and animal husbandry. According to the information from the community, 1700 people are living in the kebele.

Among The different localities that the kebele has, Dolcha is one.

Total No of Population In the PA.	*Main economical activities*	*Animal health service*	*Market access for crop and Livestock*	*Source of water for human and Livestock*	*Technical assistance received*
1700	Livestock rearing & Crop production	No	None	Ella	Development agente

Table E.1 General Information

Water for human consumption

The main sources of water for human consumption are traditional wells “Ella”. The general water situation is low in sanitation and not reliable for human consumption. The traditional wells found in the area prejudice the community for water born disease and water related sickness.

In Dolcha there are no water schemes developments built by governmental and non governmental organizations.

Water management

Due to absent of developed water schemes in the area, water management are not knew. It is needed a closed follow up to teach to the community about water management committee.

Source	*Average distance*	*Turbidity*	*Daily consumption per HH*	*Disease prevalence water born*	*Potable water scheme*
Ella	Near to the vilage	turbid	40-60 Lit	Malaria, Water related disease, Amebibiasis	No

Table E.2.Water for human consumption

Livestock

The main livestock found in the area are cows, goats, and donkeys; they have pasture in the surrounding area. Rarely, during sever dry seasons, the animals’ faeces shortage of pasture and water at these times the community leave the area to go to Genale and Wadera to look for water and pasture.

Source	*Average distance*	*Daily consumption per animal*	*Disease prevalence (water born)*	*Water scheme*
Ella	1 to 2 km	Not well known	Not reported	Not available

Table E.3 Water for livestock consumption

Animal health post is not available in the locality but they get services from the neighbouring Wadera district and Harekelo peasant association. The veterinary clinic found in Harekelo was constructed by our organization COOPI

Availability of animal post	*Availability of animal health technicians*	*Main livestock disease*	*Way of threats livestock*
No	None	-	by Vet- Scout

Table E.4 Livestock condition

Farming

The farmer in this PA practice crop production by rain fed agriculture. Their techniques are poor and the crops are mostly damaged by drought; one house hold can have 1 to 2 hectare of land for cultivation.

Average land holding per HH	*Main crop production*	*Method of cultivation*	*Purpose of crop production*	*Source of water for crop production*	*Main crop production hindrance*
1 - 2 hectare	Maize, Barley, Wheat	Manual	For personal consumption	Rain	Drought and pest

Table .E.5 Farming characteristics

The area community used to receive seeds from different governmental and non-governmental organizations.

Storage

Here also there is no as such reliable storage system; people normally use traditional storages made from woods that are not durable and there are high losses of produce due to the poor storage system.

Storage type	*Main storage pest*	*Crop pest*	*Traditional remedy*
Traditional wood type	Termites	Stock borer	Smoking the storage grain & applying of ash

Table E.6 Storage situations

F. Arda bururi

General information

Arda bururi is a place which is found approximately 9km far from Negele town. Arsi is the main ethnic group in the area. The dwellers are agro pastoralist and are depending on the animal and crop production; the vegetation coverage in the area indicates that the land is not as such reliable for a good crop production. According to the information of the community, around 1200 peoples are living in the area.

Total No of population	*Main economical activities*	*Animal health service*	*Market access for crop and Livestock*	*Source of water for human and Livestock*	*Technical assistance received*
1200	Rearing of animal & crop production	No	None	Ella	None

The no of house hold seems exaggerated

Table F.1 General Information.

Water for human consumption

Potable water for human consumption is the crucial problem in the area; the community uses water for domestic purpose from the traditional wells That even dries up during harsh environment. In that occasion they suffer with a severe water shortage.

Source of water	*Average distance*	*Turbidity*	*Daily consumption per HH*	*Disease prevalence (water born)*	*Possibility water scheme*
Ella	1 - 2km	Turbid	40liter	Dysentery	HDW

Table F.2 Water for human consumption

Water management

This locality does not have organized water management system. The community uses their traditional water sources Ela with out problems. But in the future it is advisable to establish water management system in the area.

Livestock

Even though the community practice animal husbandry it is not considerable due to unfavourable environmental situation in the area and the poor living standard of the community.

The area is mostly affected by drought as the result of this, the available livestock shifted to the neighbouring village to search pasture and water.

Source	*Average distance*	*Daily consumption per animal*	*Disease prevalence (water bar)*	*Water schemes*
Traditional hand dug well “Ela”	1 - 2 hours	Not clearly Known -	Not reported	No water schemes

Table F.3 Water for live stock consumption

There is no animal health post which gives services for the community but they get same technical assistance from the neighbouring district Negele which is 9km far.

Availability of animal post	*Availability of animal health technician*	*Main live stock disease*	*Way of threat live stock*
Not available	Not available	Not reported	By purchasing drug threaded by the herders

Table F.4 Live stock conditions

Farming system

The farming system that is practiced by the communities is rain feed agriculture but the drought that frequently is affecting the area is deteriorating the environmental condition of it. This makes the agricultural production of the village mostly used for house hold consumption.

In order to improve their agricultural production and to alleviate the shortage of food in the area, non governmental organization provided seed and food aid in the past years.

Average land holding per h/d	*Main crop production*	*Method of cultivated*	*Purport of crop production*	*Source of water for crop production*	*Main crop production hindrance*
1-2 hectare	-Maize -Wheat	Traditional	consumption	Rain	Drought

Table F.5 Farming characteristics

Storage

The storage situation is the same of the other PA's. Traditional stores are made in wood and grass; pests and rodents mostly affect the stored grain.

Storage type	*Main storage pest*	*Crop pest*	*Traditional remedy*
Traditional wood type	Rodent		Smoking grain storage

Table F.6 Storage situations

G.Buradhera

General information

Buradhera is found 15 km south west of Negele. The Lively hood of the community is agro pastoralist that based on stock raising and crop production. The village have primary school and one hand dug well.

Total No of HH	*Main economical activities*	*Animal health service*	*Market access for crop and Livestock*	*Source of water for human and Livestock*	*Technical assistance received*
	Rearing of animal Agricolture	No	None	HDW Ela	None

TableG.1General information about village

Water for human consumption

Their main source of water is hand dug well and traditional "Ela" the hand dug well was constructed by COOPI it is only for some localities. Those localities, which are living far from the HDW are obliged to use water from "Ella" (Traditional well), which was not good for human consumption

Source of water	*Average distance*	*Turbidity*	*Daily consumption per HH*	*Diseasing breveting (water bar)*	*Possibility water scheme*
HDW Ela		no	40 lit	Not reported	HDW

TableG.2 Water for human consumption

Water management

They have a water management committee, which consists of chairperson, secretary and technician. The committee in general control the water management activity in the area such as

- To collect money from water sell
- To use the water supply system to the community etc.

This water management committee has opened bank account. It is better to strength this management committee.

Farming system

The farmer carry out crop production by rain fed agriculture. Drought and unfavourable environmental condition in the area affect their crop production

The farmer practise traditional agricultural activates

Average land holding per h/d	*Main crop production*	*Method of cultivated*	*Purport of crop production*	*Source of water for crop production*	*Main crop production hindrance*
	Maize, Been, Teff, & Barley	Traditional	For hours of consumption For soil	Rain	Drought

Table G-3 Farming characteristics

Livestock

This community has a good live stock population in the area when compared to other PA's. The main problem in the area is lack of pasture during dry season. The shortage of pasture in the surrounding area has created shifting of the livestock to other villages like Dida Liben.

Source	*Average distance*	*Daily consumption per animal*	*Disease prevalence (water born)*	*Water schemes*
Traditional hand dug well "Ela"	It take 30 minutes		Not reported	No water schemes for animal consumption

Table G.4 Water for live stock consumption

In this locality there is no veterinarian clinic, even they do not have technician to threats their animals. The herders treated the animals.

The herders are purchase drug (tablet) from the town. If the situation is severe they will go to Negele. The community have welling to have animal health post

Availability of animal post	*Availability of animal health technician*	*Main live stock disease*	*Way of threat live stock*
Not available	Not available	Not reported	By purchasing drug threaded by the elders

Table G.5 Live stock conditions

Storage

The storage situation is the same as the other PA's. It is traditional store mad from wood and grass pests and rodents mostly affect the stored food

Storage type	*Main storage pest*	*Crop pest*	*Traditional remedy*
Traditional wood type			Smoking grain storage

Table G.6 Storage situations

H. BOKOLA

General information

Bokola is one of the PA's found in Guji Zone of Liben Woreda. The main ethnic group in the area is "Guji" and the livelihood of the community mainly based on production of crop and rearing of animals. The community is estimated around 3,900 people who are living in the area and the population settlements are very scattered.

Bokola PA has six localities.

1. **Harolakole**
2. Barbarssa
3. Homachessa
4. Ara
5. Dhebo
6. Harobore

N.B Haralakole: is the place where COOPI planed to dig the hand dug well.

Total No of HH in the Kebele	*Main economical activities*	*Animal health service*	*Market access for crop and Livestock*	*Source of water for human and Livestock*	*Technical assistance received*
600	Livestock Agricolture	No	Hareklo which is 30kms far	Ela Pond	None

Table H.1 General Information

Water for human Consumption

The community has basic problem concerning water: at the time being the population is fetching water (for human and livestock consumptions) from traditional had dug well "Ela". Normally the traditional Ela dries during dry seasons, due to this the community is obliged to look for water from the neighbouring PA's like Wadera which is 50 Km far from the PA.

Source	*Average distance*	*Turbidity*	*Daily consumption per HH*	*Disease prevalence water born*	*Potable water scheme*
Traditional well	3-5 km	Turbid	40-60 Lit	Ambiassis Geardiassis	Not available

Table H.2.Water for human consumption

Water management

Water management committee in the area are not well known, because there are no water scheme constructions by governmental and non governmental organizations. There community don't have organized water management system, but traditionally they manage their water source properly.

Livestock

Animal husbandry is the main farming activity in the area. The farmers have owned caws, goats, sheep, and donkey. The livelihood of the community is basically based on the product and sells of animals. During long dry season the livestock shifted to Awata River to search water and pastures.

Source	*Average distance*	*Daily consumption per animal*	*Disease prevalence (water born)*	*Water scheme*
Ela	Near to the village	It is not well known	Not reported	Not available

Table.H.3. Water for livestock consumption

Veterinary clinic in the area is not available even the community does not get any technical assistance for their animals; some times the governmental organizations are giving vaccinations for their livestock, but the inconstant follow up given did not permitted to record the benefit of this activity.

Availability of animal post	*Availability of animal health tenancies*	*Main livestock disease*	*Way of threats livestock*
No	None	Different kind of disease	Vaccination serves

Table H.4 Livestock condition

Farming system

Farming activities in the area are not as such considerable. The population is commonly cultivating 1.5 Hectare of land. The products are not exceeding from their consumption. This is as the result of drought and the nature of the soil that is not good for crop production. Some farmers are using fertilizers like urea and DAP in order to improve their production.

The community practice rain feed agriculture.

Average land holding per HH	*Main crop production*	*Method of cultivation*	*Purpose of crop production*	*Source of water for crop production*	*Main crop production hindrance*
1.5 hector	Maize, Wheat, & Teff	Manual	For consumption	Rain	Drought and Termites

Table H.5.Farming characteristic

Storage

In this area some of the farmers have traditional wood type storages that are not suitable to protect products by crop pest; at the same time the community have no means to manage store problems.

Storage type	*Main storage pest*	*Crop pest*	*Traditional remedy*
Traditional wood type	Termites		Not reported

Table H.6.Storage situation

I. Nura humba/Mede

General information

These two sites are located in the same Peasant association Nura humba and are 8 km apart and it was supposed that all the information's are the same.

The other PA, where the assessment was done was Nura humba. The main ethnic groups who are living or found in this area is Guji, this people are agro pastoralist, in which they are depending on crop production and animal production for their livelihood. According to the interview, 3800 people live in the area that is settled very scattered in the locality.

This peasant association has seven localities.

1. Kahale
2. Goda
3. Debesa
4. Kereka
5. **Madhaday**
6. Hoole
7. Coale

Total No of HH in the kebele	*Main economical activities*	*Animal health service*	*Market access for crop and Livestock*	*Source of water for human and Livestock*	*Technical assistance received*
420	Livestock rearing & crop production	No	Negelle & Harekelo	HDW, Ela, Pond, & Surface water	None

Table I.1 General Information

Water for human consumption

Most of the community of this PA normally depends on the Traditional wells (Ela) and pond as a water source for both domestic and animal use. Traditional wells and pond are not sufficient for their use.

Even though save the children constructed a hand dug well in one locality ('ketena'), the remaining locality in the PA have no any accessibility to potable water.

As described above the people are scattered. This dispersion could complicate the realization of water scheme for potable water to the entire locality. To avoid this complication; our organization has planed to dig two potable water scheme in different localities. One in the main peasant association ***Nurahumba*** and the other in ***Medhade*** locality

Water management

Water management is not well known in this area. Farther more activities needed to aware and set up management system

Source	*Average distance*	*Turbidity*	*Daily consumption per HH*	*Disease prevalence water born*	*Potable water scheme*
HDW, Ela & Pond	Near to the localities	Turbid	20-40 Lit	Not reported	HDW

Table I.2.Water for human consumption

Farming

The farmers in this PA practice crop production by rain fed agriculture. Their techniques are poor and the crops are mostly damaged by drought; one house hold can have 1 - 2 hectare of land for cultivation. They get seed from the market.

Average land holding per HH	*Main crop production*	*Method of cultivation*	*Purpose of crop production*	*Source of water for crop production*	*Main crop production hindrance*
1-2 hector	Maize Wheat Teff	Manual	For consumption	Rain	Drought and pest

Table .I.3 Farming characteristics

Livestock

The community has different kinds of animals like caws and shoats. During the rainy season the livestock have a good pasture but during the dry season they are in trouble due to lack of pasture and water. In the later time they should search water and pastures by moving to the neighbour villages.

This PA has no animal health post some time their livestock get treatment from the government. If they need farther more treatment they obliged to go to Negelle.

Source	*Average distance*	*Daily consumption per animal*	*Disease prevalence (water born)*	*Water scheme*
Pond Ela Surface water	Around the village	Not well known.	Not reported	Pond constricted by EGS

Table I.4 Water for livestock consumption

Availability of animal post	*Availability of animal health technicians*	*Main livestock disease*	*Way of threats livestock*
No	None	Not reported	By vet- Scot

Table I.5 Livestock condition

Storage

Here also there is no as such reliable storage system. People use traditional storage made from woods that are not durable and there is a high loss of produce due to the poor storage system.

Storage type	*Main storage pest*	*Crop pest*	*Traditional remedy*
Traditional wood type	Termites	Stock borer	Smoking the storage grain

Table I.6 Storage situations

J. Wofe

General information

Wofe is the place which is located on the periphery of Negele town near the military camp; it is under kebele 04. Most of the residents of the area are farmers and Pensioner. They administer their family from a very small monthly pension payment from the government, from agricultural product sells and pity trade. According to the information gathered from the key informants total number of house hold found in the area is 980. One house hold can have 4 to 6 children.

Total No of HH	*Main economical activities*	*Animal health service*	*Market access for crop and Livestock*	*Source of water for human and Livestock*	*Technical assistance received*
980	Pity trade Agriculture	Available	Yes	Ella	None

Table J.1General information about village

Water for human consumption

Potable water for human consumption is the crucial problem in the area; they are using water for domestic purpose from the traditional wells that was constructed by Red Cross society more than decade ago. But at present this well is not well functional.

Source of water	*Average distance*	*Turbidity*	*Daily consumption per HH*	*Disease prevalence (water born)*	*Possibility water scheme*
Traditional well	Near the village	no	40-60lit	Ambibiassis Gardiassis	HDW

Table J.2 Water for human consumption

Water management

Concerning water management committee in this area it is not known. Strong attention is needed to establish the system in this area. If it is organized and well trained they have a good willing and initiation to have a water management system.

Livestock

Animal husbandry that the community practice is not considerable due to the poor living standard of the community. Some of them rear cattle for their farming activity.
They get water for their animals from the traditional well. As the village is near to the town they obtained any technical assistance from the concerned body.

Availability of animal post	*Availability of animal health technician*	*Main live stock disease*	*Way of threat live stock*
Get service from the town	Get service from the town	Not reported	Treated at health service in the town

Table J.3 Live stock conditions

Farming system

The farming system that is practiced by the communities is rain fed agriculture but the drought that frequently affecting the area is deteriorating the Production. This makes the agricultural production of the village nearly insufficient for the daily consumption.

In order to improve their agricultural production and to alleviate the shortage of food in the area, they advised to practice vegetable production around their village.

Average land holding per h/d	*Main crop production*	*Method of cultivated*	*Purport of crop production*	*Source of water for crop production*	*Main crop production hindrance*
1-2 hectare	Teff, Barely, Maize, & Wheat	Traditional	consumption	Rain	Drought

Table J.4 Farming characteristics

Storage

The storage situation is the same as the other PA's. Traditional stores are made from wood and corrugated sheet of iron; pests and rodents mostly affect the stored product.

Storage type	*Main storage pest*	*Crop pest*	*Traditional remedy*
Traditional wood type	Termites	Stock borer	Smoking grain storage

Table J.5 Storage situations

K. Buledi/Haro/

General information

Buledi is found 4 km far from Negele town. The Lively hood of the community is agro pastoralist that based on stock raising and crop production. They also generate income from sells of goods. Near to the village they have primary

school and one hand dug well constructed by SCF-US (Save the children federation). The people living in this area are ethnically different from the other peasant associations found in the district, they are Somali. The peasant association have nine localities and the population size is very large. There are also a large number of displaced people living adjacent to the area (Haro). According to the information got during the assessment around 7000 peoples are estimated living in the area including those who are displaced from Somalia.

Total No of population	*Main economical activities*	*Animal health service*	*Market access for crop and Livestock*	*Source of water for human and Livestock*	*Technical assistance received*
7000	Rearing of animal, crop production, & Pit trade	No	Accessible	HDW Ela Pond	None

Table K.1 General information

Water for human consumption

Their main source of water is hand dug wells, pond and traditional "Ela". The hand dug wells were constricted by SCF and Islamic aid. The constructed had dug well is used for some localities. Those localities, which are living far from the HDW are obliged to use water from "Ella" (Traditional well) and ponds which are not good for human consumption because they are unprotected and polluted by animals and human waste. Most of the time they have been suffering from water borne and water related diseases.

Source of water	*Average distance*	*Turbidity*	*Daily consumption per HH*	*Disease prevalence*	*Possible water scheme*
HDW, Ela & Pond	0 - 4km	Most of the water sources are turbid	40 to 60 lit	Ambibiassis Malaria Gardiassis	HDW

Table K.2 Water for human consumption

Water management

Even if they have a water scheme in the area they do not have well organized water management system. In the available water scheme in the area they assign a care taker to open and close the water sources at the needed time and to collect money from the beneficiaries. The collected money is used only for salary payment to the care taker. They do not know systematic and proper financial management system. The initiation of the community towards the water management system is good but farther more attention is required to create well organized management structure in the area.

Farming system

Farming activities in the area are not as such considerable. Those who practice agricultural activity are less in number. They mostly cultivate 0.5 to 1

Hectare of land. The products are not exceeding from their house hold consumption.

The farmer carry out crop production by rain fed agriculture. Drought and unfavourable environmental condition in the area most of the time affect their crop production.

The farmer practise traditional agricultural activities

Average land holding per h/d	*Main crop production*	*Method of cultivation*	*Purpose of crop production*	*Source of water for crop production*	*Main crop production hindrance*
0.5 to 1 hectare	Maize, Wheat, Teff, & Barley	Traditional	For house hold consumption	Rain	Drought

Table K-3 Farming characteristics

Livestock

They practice animal husbandry but it is insignificant. They have a few numbers of different kinds of animal like camel, caw, and shoat. The community use their products for house hold consumption.

Source	*Average distance*	*Daily consumption per animal*	*Disease prevalence (water bar*	*Water schemes*
Traditional hand dug well "Ela" Pond	Near to the village	Not clearly known	Not reported	No water schemes for animal consumption

Table K.4 Water for live stock consumption

Concerning animal health service the herders get from Negele town which is 4km far. They do not have problem related to this service.

Availability of animal post	*Availability of animal health technician*	*Main live stock disease*	*Way of threat live stock*
Not available	Not available	Not reported	By purchasing drug threaded by the elders

Table K.5 Live stock conditions

Storage

The storage situation is the same of the other PA's. It is traditional store made from wood and grass and pests and rodents mostly affect the stored product.

Storage type	*Main storage pest*	*Crop pest*	*Traditional remedy*
Traditional wood type			Smoking grain storage

Table K.6 Storage situations

L. Conclusion

Due to unavailability of well organized water scheme in the area, in all intervention areas shortage of water is the critical problem of the community. All the communities give the 1st priority to have potable water scheme in the surrounding.

Even though it need detail and well organized assessment techniques to know the general situation of the community, during our assessment the following major problems were detected in the intervention areas

Constrain regarding water ands pasture

Though in the areas different governmental and non-governmental organizations constricted hand dug wells for the consumption of the community, still water and pasture scarcity occurred during dry season. Especially, the live stock shift to the neighbouring villages to look for water and pasture.

The water management committee formed previously in all intervention areas are not seriously following and managing the scheme they are expected to do so. It is advisable to organize and strengthening of the formerly constituted water management committees by giving a training to remind and/or create awareness about their duties and responsibilities.

Constrain regarding public infrastructure

Public infrastructure like school, health posts for human being as well as for animal are not available. The absence of this infrastructures in the area aggravated the problems facing the community i.e. made the community to live a difficult life especially due to the absent of clinic in the area the people suffer from endemic water related disease and malaria.

Constrain regarding farming activities

The farming system in general is mixed including crop production (maize, wheat, teff and barley etc) and animal production (caw, camel goat and etc)

The crop production is based on rain fall most of the community is not prefer to use fertilizer due to high price of the fertilizer.

The storage models are traditional and not improved, with important loss due to pest and rodents. The out come of crop production is for consumption and those closer to the main village & road are also for sell.

Generally all of the PAS we were visited are our previous intervention areas, so they are familiar with our organization and are voluntary & have a good willing to help and participate to gather with us eg. Muco.

Annex 3: Hydrogeological Assessment Report

COOPI
Drought consequence Alleviation Project in Borena zone

Hydro geological and Geophysical Assessment Report carried out in Liben woreda For Hand Dug Well Sitting

August, 2003

Negele Borena

Table of Contents

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1 INTRODUCTION

1-1 Back Ground Of The Project

Liben Woreda is one the eight woredas found in Gujjii zone of Oromia National Regional State. The woreda is dominantly populated by clans of Oromo, named as Gujjii, Borena and Arsi. Clans of Somali and other nationalities also exist in the area, but they are minor as compare with the Oromo clans. The livelihoods of the community mainly depend on agro pastoral way of production.

Liben woreda is one the woredas those usually hit by recurrent drought and the main factor for the recurrent drought phenomenon could be the erratic nature of the rain fall and improper use of water resources. As a result it is common to see in side the community the problems related with the scarcity of perennial potable water source.

Several NGOs and Governmental organizations are actively working on different development sectors to alleviate the problems of the community of the woreda. COOPI is one of them and has been working on different development sectors in Liben woreda since several years ago. Water sector was one of the main sectors of intervention for COOPI, and still the organization is actively participating in the alleviation of the stress imposed on the community as result shortage of potable water sources.

Recently the organization formulated a project under head title of 'DROUGHT CONSEQUENCES ALLEVIATION IN BORENA ZONE', which targeted on the alleviation of the problems that could happen after the drought period of 2001/2002. The main frame work of the project comprises the construction of ten hand-dug wells equipped with hand-pumps and other two hand-dug wells equipped with solar power driven submersible pumps.

The project runs by fund secured from USAID-OFDA.

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1-2 Objective

The objective of the assessment is to identify twelve places where potable water source either not existing or not sufficient in order to carry out potable water intervention project.

1-3 Methodology Applied

Office work

All available previous work documents regarding the geological and hydro geological condition as well as metrological data of the area revised. It includes referring the hydro geological and geological survey reports written by indigenous and foreigners for different purposes, revising different maps, revising several water well construction reports in the woreda.

Most of the previous works are concentrated on the basement work, since these works are done for preliminary exploration of metallic ore deposits and the other few are targeted for research point of view. Most of the works on marine succession of the area were targeted on oil exploration and the others for lithological correlation of the set up marine succession of Ethiopia with east Africa. Thus, the available published maps are onto large scale and only give general view about the geological set up of the area. AERIAL PHOTOGRAPHS, LANDSAT images are referred for further better understanding of the area.

Fieldwork

The deskwork in the office was followed by successive preliminary field visit in order to understand the condition of the specific areas; those were proposed for water intervention in the project genesis. More detail field geological and hydro geological observation carried out on those areas that came out as prospective areas for shallow ground water exploitation.

Finally based on above observations geophysical survey using electrical method conducted in areas where the previous geological and hydro geological observations indicate promising feature. Then after, based findings of the geophysical survey the specific sites are selected.

remark- the specific site selection not only depended on the hydro geological feature of the area, but also socio-economic condition of the specific area, permission from the respective governmental organization as well as the interest of the community towards the project were consider.

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Materials used

Topographic map of scale 1:50,000 are referred since these are very helpful for understanding of the general morphologic out look as well as drainage net work, and to establish small base map. Field materials, such as COMPASS, GPS, ALTIMETER were used understand the exact location of each feature on the map. AERIAL PHOTOGRAPHS, LANDSAT images are referred for further better understanding of the area.

For geoelectrical survey data acquisition, ITALIAN MADE GEOPHYSICAL MACHINE called PACI were used for recording the variation of the potential difference with respect to applied current. Then the recorded data further analyzed in office using different software packages and finally interpreted in to lithological layering.

1-4 The scope of the report

This report comprises the technical aspect regarding the hydro geological and geological survey carried out in Liben woreda in to select twelve well sites. The general description is categorized in to four AREAS and these are:

- The Around Bura Dhera Is the representative for description of by southern of Negele.
- North of Harekelo- Include the area from Harekelo towards North.
- North of Negele up the road to Genale road includes the area bounded by the main Bitata-Negele road and by Bitata-Genale road, and it comprises the area by north of Negele.
- By west of the road includes all the areas by west of the road: from the south of Harekelo up to west of Negele

1-5 Physical Description Of The Area

1-5-1 Location and accessibility

Gujii zone is one of the administrative zones of Oromia national regional state. The zone consists of eight woredas and Liben woreda is one them. Liben woreda located in the south part of the zone and it bordered by: Somali national Regional state by south and south east, Borena zone and Shakiso-Odo woreda by west, Bale zone by north and east and Wadera woreda by northwest. The capital of the district is Negele and it located by south of Addis Ababa at 595km distance. The capital of the district is accessible by partly by all weather gravel road and partly by asphalt road.

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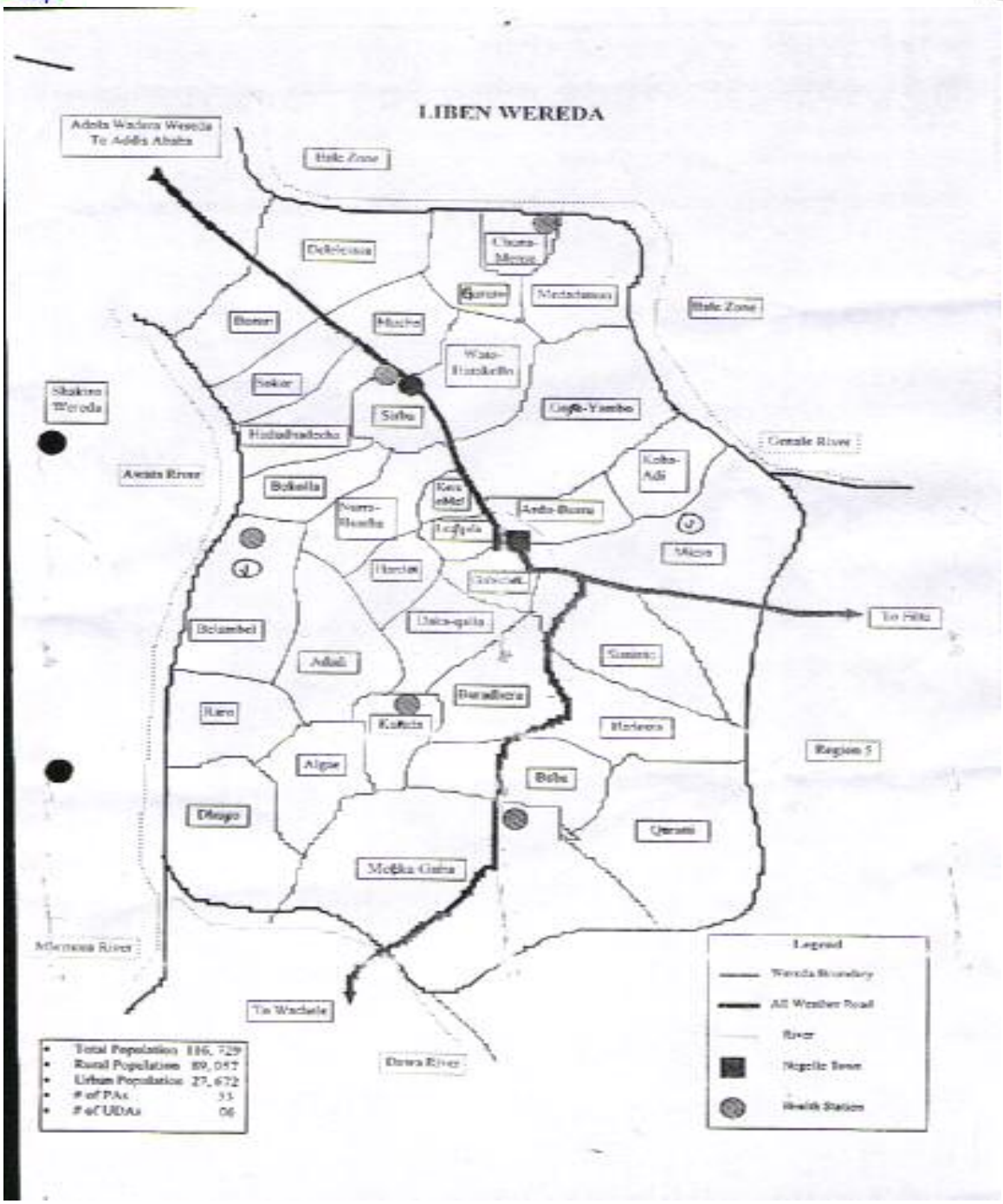

Fig-1 Location map of the district, not on to true scale

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1-5-2 Climate

In 1996, the zonal department of Planning and Economic Development published one analytical report that attempted to show the climatic condition of the zone based on meteorological data collected by NMSA* owned six meteorological stations that are located at different places in the zone.

Among the stations, Negele observation station is the one and it is the basic reference to establish the climatic condition of the town as well as its surrounding. However, in the report it is remarked that due local topographic variation and low density of meteorological stations the data could be not sufficient to describe precisely the metrological parameters in the surrounding countryside.

The available meteorological report show that the recorded minimum annual precipitation depth is 592mm*,that is in 1988 and the maximum recorded value is 1381mm, that is in 1981mm.in general the mean precipitation depth for this station was 921mm and the average deviation for each year's values from the mean is found to be 169mm.

According to the report, the town and its surrounding has two rainy seasons (bimodal rainfall pattern), which are locally known as "Ghanna" and "Hagayya". "Ghanna" is big rainy season that, in normal years, begins in March and ends in May. The proportion of the rain that falls in this season is about 56% of the total annual rainfall. "Hagayyaa" is the second and the small rainy season that, in normal year, begins about in the end of September and ends in November. The proportion of the rain that fall during this season is about 32% of the total. The remaining 12% of the total annual rainfall receive during intermediate seasons, particularly the June-July "Soorroo" rains.

The report also shows that the town and its surrounding experience a big range of temperature variation through a day that range from 16^0 to 28^0 with relatively lower monthly variation. The calculated annual mean-maximum, mean, mean-minimum for this station is 16^0c, 22^0cand 28^0c, respectively.

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1-5-3 Topography and Drainage

The topography of the district can be classified in to two and these are the eastern and southeastern flat forms and the northern, eastern and southeastern rolling landforms.

The area by east and south east of Negele town characterize by flat plane of sedimentary succession with mean elevation around 1550m above sea level. Un likely the northern, western and southern part of the district characterize by rolling and undulating land forms.

River Awata, Dawa and Genale are the big perennial rivers in the area and these rivers form the boundary of the district by west, south and east, respectively. There is no other perennial river in the area; however, intermittent streams are very abundant in the Gneissic terrain of the district e.g. river Hardot and Migna. Unlike to in basement terrain, in the sedimentary terrain the existence of developed stream lines is rare.

1-5-4 Geology Of The District

Crystalline basement rocks in association with intrusives and Jurassic-cretaceous marine sedimentary successions are the main units in set up of the geology of the district. The Cenozoic volcanics as well as late deposits are also play it's apart in the set up the geology of the area. The following map shows the general geological set of the area (the shaded part nearly represent that of Liben district, but not to be consider as exact map of the whole district).

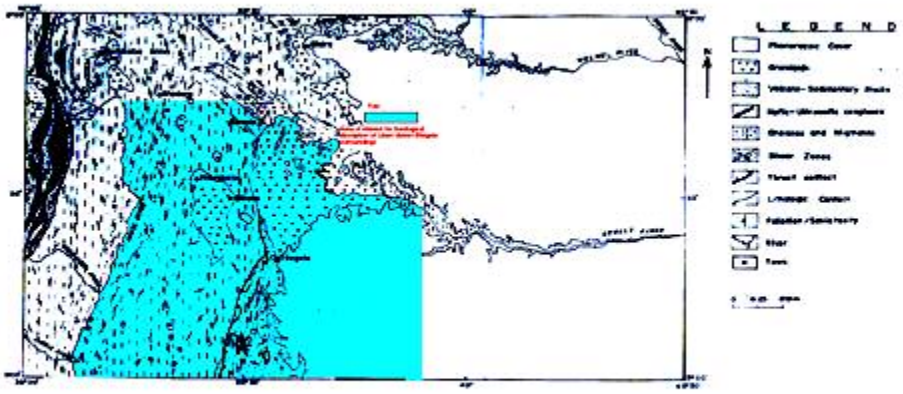

fig-2 simplified geological map of the area adapted from report of geology of Negele area by Tadesse and Tilahun (1998)

1-5-5-a- Crystalline Basement Rocks and Associated Intrusives

The crystalline basement rocks are the prominent rocks that cover wide are of the Northern, western, south and southwestern part of the district. These rocks are well exposed along big perennial river valleys.

The crystalline basement rocks of the area comprise the protorezoic age high grade and low grade belts in association with pre-, post- and syn- tectonic intrusives. The high-grade belt consists of gneisses; schists, migmatite, and it occupy the lower Litho-stratigraphic position. While the low grade belts are mainly metavolcano-sedimentary rocks and mafic-ultramafic complexes.

High Grade Rocks

Algae group, Awata group and Wadera group rocks are the most pronounced rock units that formed the high-grade belt of the area from older age to younger, respectively. The high-grade basement rocks are mainly exposed in the western, north western and southeastern part of the district. Beside these, the deep cut of Genale River also exposed the units. According to Kazmin,1972; Kozeyrev et. al. 1985;Mengesha et.al.1966 these rocks are dated as Archean to mid Proterozoic and they are separated from each other by marked unconformities which adapted for classification.

- Algae Group- consists of biotite-hornbelnde gneiss with subordinate biotite, hornblende-biotite, quartzo-feldspatic gneiss, biotite, deformed and/or undeformed biotite granite as well as migmatite. In addition to the gneiss rocks, talc-tremolite schist occurs as minor lenses. The rocks this group are the most prominent rock units in terms of aerial coverage. It extensively exposed as a wide belt, running from north to south in the western part of the district and it exposed along the valley of river Genale. It often cut by discordant and concordant pegmatitic and quartz vein and veinlets. In geo-chronological order, it represents the oldest rock of the area.

- Awata group- is constituted mainly of biotite-plagioclase-microcline-quartz mylonite with presence of migmatized hornblende-biotite gneiss and hornblende gneiss. It exposed in the western part of the district in side Wadera shear zone. The contact with adjoining unit such as Algae and Wadera groups is not distinct. In some places, it grades in to Wadera unit and

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display a reduced grain size and mafic mineral proportion. The presence of asymmetric quartz and feldspar porphyroblasts consistently in the unit indicate the abundance of sinisterial movement in the unit.

- Wadera group- is consists of dominantly quartzofeldspatic mylonite, with minor presence of quartzofelspatic gneiss, biotite-plagioclase-microcline-quartz gneiss and biotite granite. It exposed as discontinuous north-south running belt in western margin of the district, juxtaposed with rocks Kenticha low-grade belt. This unit uniformly dips to the west and it interpreted to had been gently under thrust beneath Kenticha low-grade rock assemblage. Morphologically it forms prominently sharp crested ridge that runs from north to south and this morphological feature is peculiar to the Wadera group in Wadera shear zone. Apart from this the unit occupies relatively elevated topography than the other high grade map able units.

Low Grade Rocks

The low-grade include rocks of Adola and Mormora groups that are metavolcano-sedimentary rocks and mafic-ultramafic complexes. These low-grade assemblages are classifies as upper complex of late Proterozoic age, kazmin, 1972; Kozyrev et.al. 1985; and Mengesha, et.al.1996. The rocks of this group occur as small patches in the high-grade unit, in the northern part of the district. While in the southwestern part of the district, they become more prominent especially along Bulbul thrust belt by south west of Negele.

- Adola group- consists of talc schist, chlorite-tremolite-talc schist, chlorite-actinolite schist, actinolite schist and meat gabro. Around Bulbul area the unit become extensive and frequently truncated by deformed and often altered biotite granite and it unconformably covered by Jurassic-cretaceous limestone succession by east. This unit pinch out north of Negele town and widens southwestward. Beside it appear as lenses inside high grade rocks. In the area near to Bulbul trust contact it shows pencil like structure especially along north of the road near Bura Dera.

- Mormora group- it consists of quartz-biotite schist, quartz–sericite schist and garnet-staurolite-quartz-biotite schist with minor intercalated actinolite and chlorite schist. It extensively exposed in Bulbul low-grade belt. And as minor intercalation in

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Wadera group. It is strongly sheared and foliation is often crenulated. This group is dominantly composed of quartz-biotite schist.

Intrusive rocks

The intrusive rock in the area is dominantly granitic in composition with occasional variation in the relative abundance of quartz, K-feldspare and plagioclase crystal. These granitic rocks of variable dimension intruded various gneissic and migmatitic rocks of gneissic terrain as well mafic-ultra mafic and volcano sedimentary of low-grade belts. The intrusives are more abundant in the gneissic terrain as compare to the low-grade belts. Granite classification using AFM diagram by worku (1996), indicate the granitic rock are calc-alkaline in character, possibly I- and A- type. Based on mineralogy, texture and structure the gneissic intrusives are classified in to three subgroups.

- Syn-tectonic biotite granite- this unit very well exposed by north of Negele town as well as by south of Negele near south of BuraDhera Village. It is pinkish grey medium to coarse grained and weakly foliated. The foliation pronounced towards the contact with other gneissic unit. Petrographically it shows considerable variation in modal composition that ranges from granodiorite to K-feldspar rich granite in the Streckeisen plot diagram. Preferred orientation of biotite, micrographic intergrowth of quartz and feldspar are the common textural feature in the unit.

- Post tectonic biotite granite- this unit covered wide area between Bitata village and HareKelo. It formed elevated land and hills. It is pinikish grey, medium to course grained, in equiangular and massive. It commonly shows micrographic inter growth of quartz and plagioclase crystals. The contact of this granite pluton with intruded country rock in generally not sharp.

- Post tectonic pegmatoidal granite- exposed northeast Negele town around Chechfe. This unit formed rugged topography. It has gradational contact with post tectonic granite unit and has sharp contact with syn-tectonic biotite granite. It is characterize by large grains of microcline and the random and abundantly distributed coarse microcline, plagioclase and quartz phenocrysts impart pegmatitic appearance to the rock. Based on the mineralogy and textural evidences, this unit interpreted as the last post-deformational intrusive body emplaced in the

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Negele area and shows a variation from K-feldspar to quartz rich.

The various structures, such as folds, foliation, lineations, shear zones and lineaments displayed in uncovered crystalline basement of the area were developed through out the progressive syn-orogenic (folding and thrusting) and post orogenic (shearing) deformations. The variable size shape and orientation of these structures are attributed to the nature, style and direction of deformations results them, the rheological character of the rocks subjected to deformation and crustal depth. The large and small-scale structures in the area reveal the prevailing ductile and brittle-ductile deformation at deeper crustal level.

As the consequence of the east west compressional tectonic regime during orogenesis, a repetitive north south oriented antiform, thrust and shear zones and related structures were generated. The east west directed compressional deformation resulted in East Africa Orogen in late Proterozoic in which the southern Ethiopia segment is apart (Vail, 1983; Shakleton, 1986, 1994, 1996; Key et.al. 1989 and others).

Previous reports such as that of Amenti et.al. (1992) and Woldegebrial et. al. (1994) suggested six-phase deformation. On other hand Hambisa et.al.(1997) in compilation work of Dodola area suggested two phase of deformation have affected the metamorphic rocks of the area. According to Tadesse and Yihune, in the report of Geology of Negele area, four progressive episodes of deformation recognized.

Although field evidences for the first deformational phase is scarce because of obliteration and superimposition by the subsequent deformational phases, the first phase of deformation resulted in folding and shearing zone of Negele area. A westerly and easterly dipping incipient axial planar cleavage, isoclinal folds of vertical axial surface and horizontal fold axes together with an easterly and westerly dawn plunging mineral elongation lineation generated in the gneissic terrain thought to be resulted from first phase deformation that is compressional deformation.

The second phase of deformation can regard as a final episode of folding event; it is progressive and coaxial with the first phase deformation. It resulted in tightening of the former folds that are gentle to open and linear structures developed during the second phase have north-south trend general alignment. The folds developed by the second phase are north south trending, macro to mesoscopic, sub horizontal up right, over turned and they are represented by repeated synformal and antiformal structures. These folds can be considered as enhanced forms of those folds originated from phase one deformation. The foliation of the second phase deformation is an axial surface cleavage to the non-

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planar the second phase fold axial surfaces and it is represented by interbedding of mafic and felsic layers as well as schistosity. It has meridional to sub meridional trend, moderately to steeply dipping to and east. Lineation is represented by mineral aggregate, mineral elongation and crenulations. These linear elements are gently plunging to the northwest and northeast.

The third phase of deformation was been dominated by thrusting and strike-slip shearing event. The seal of this deformational episode is prominent on low-grade belt as well as on the gneissic terrain along the trust front of Bulbul and Kenticha. Eastward and westward verging with north-south trending sub horizontal fold axis tighter inter limb angle, and mesoscopic reverse drag folds are generated in this episode. Mylonitic planar surface is found imparted in the rock of gneissic terrain (Algae group and Wadera group rocks) localized in Kenticha and Bulbul thrust belt. The fact that reactivation of the thrust plane and significant lateral displacement due to probably ramp structures on the trust plane of under-thrusted plate causes the formation of ductile to brittle ductile thrust related shear zones. This include the formation of 7Km wide and 85Km log Kenticha thrust contact as well as the formation of 5Km wide and 55Km long Bulbul thrust contact. Kenticha trust contact characterized by asymmetric interafolial Z- fold, transported quartz boudins, steepened shear fabric, north-south sub horizontal stretching lineation. While Bulbul shear zone characterize by frequent occurrence of mesoscopic interafolial Z- folds, steep shear fabrics transported quartz vein boudins, asymmetric feldspars and quartz porphyroblasts, north-south sub horizontal stretching lineation and pencil structures.

The forth deformational phase resulted in the formation of north-south trending major strike-slip shear zone, referred as Wadera shear zone and associated NW-SE and NE-SW trending , Abulo Rukisa-Waduma and ZembabWhuha –Biddimo conjugate shear zones, respectively. Wadera shear zone is north-south trending sinstral strike-slip shear zone and is is one of the most prominent Orogen-parallel strike slip shear zone in southern Ethiopia (Worku,1996: Amenti:1996).it includes tight to close, vertically up right to steeply inclined similar folds of 0.5-1m amplitude and up to two meter wavelength. Foliations of this generation are commonly display as mylonitic foliations or shear fabrics. Stretching and mineral elongation lineations are the common lineations. Abulo Rukisa-waduma shear zone is interpreted as synthetic strike-slip shear zone to Wadera shear zone and this shear plane extends from north west to south east at an acute angle(<30) to Wadera shear zone.

Ductile, brittle-ductile and brittle faults affected the late Proterozoic crystalline basement rocks of the area. These faults have generated through out the different episodes of deformation. However, the majority of them are interpreted to be associated with phase four deformation. Only few are generated by local extension and later regional up lifting and subsidence associated with east African rifting. North-south trending brittle- ductile faults are abundant in the area

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and there intensity increase towards west. Most of North-south trending fauls are restricted to Wadera shear zone. NW-SE and E-W faults are brittle ductile, which affect the basement rocks across Wadera shear zone. These faults have length ranging from 1km to more than 40Km (eg. Algae and Mugayo faults are the prominent among others). These faults have sharp, linear fault surface, offset of lithologic contact along the fault plane is notable and indicate both sinisterial and dextral sense of movement.

1-5-5-B- The Sedimentary Successions

The sedimentary successions of the area can be broadly classified as:

- Paleozoic clastic sand stone
- Mesozoic limestone
- younger deposits

Paleozoic Clastic Sandstone

It is composed of cross-bedded sandstone, and it is the representative for continental clastic sedimentation of Paleozoic. The exposure of this layer recorded near to Negele town at Gobicha and at Mene Kubsa (BuraDhera) locality that is by south west of Negele. It occur as discontinuous patch, often missing and can be consider as minor unit in terms of thickness and extent of aerial coverage.

It is cross-bedded with massive beds with reddish brown to buff white colors. It is well sorted, medium grained and its thickness never exceeds 20m. Usually rests unconformably on the basement rocks and loosely packed conglomerate layer composed of rounded and granules of quartz grains and fragments of basement rock are common in a place where it lies on the basement rock.

The cross bedding nature of the deposit and the absence of marine fossils indicate that this sand stone may have been deposited in high-energy terrigeneous and fluviatile depositional environment.

Limestone

The Mesozoic marine successions overlie the underneath clastic sedimentary layer in the area and very volumetrically covered the western and the southwestern part of the district. The contact of the Mesozoic succession with the bottom Paleozoic clastic sedimentary layer is gradational, and its thickness may reach in access of 700m.According to Tadesse and Melaku, 1998 this marine succession sub divided in to two distinct units namely Jerder limestone and Melmel limestone from the bottom to top.

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Jerder limestone form the lower most succession of Jurassic limestone and it consists of mudstone, fossil reef limestone, mudstone-wackstone, black shall, dolomitic wackstone, sandstone and conglomerates.

In the report of geology of Negele area, by Tadesse and Melaku 1998, Jerder limestone further divided in two based on the existence of thirty-meter thick, laminated, fine grained and fissile black shale. This balck shale layer is found to consist index fossile of ammonites, belemenites and fonaminifera specious of late calovian to later oxfordian age (Ali kasim et al.(1987a,1987b, in Bosellini,1989)). The presence of the black shale layer indicates deposition in the deep-sea environment and possibly maximum depth of the sea record in the area.

The other main succession is Melmel lime stone limestone succession. This succession covers a wide area in northwestern western south western of the district. Melmel succession differentiate from the under lain Jerder by clear angular unconformity. Melmel limestone further subdivided in to two-sub group based on the conglomerate horizon that appears between the upper part and lower part.

The lower part of Melmel comprises pelletal oolitic grainstone, Mudstones, alternate beds of wackstone to packstone and packstone to grainstone and conglomerate. The grainstone are dull grey to reddish yellow and form parallel and planar beds. There thickness ranges from micrite to dismicrite and then to fossiliferouse micrite. The mudstones are reddish yellow in color and they are horizontally layered massive beds. Texturally they area dominantly micrite, dismicrite and they are fossiliferouse. The alternating beds of wackstone-packstone-grainstone consists of horizontally bedded dull white to reddish yellow packstone to grainstone from the bottom and fine to medium grained yellowish white wackstone in the middle as well as yellowish brown, fine grained massive, hard, horizontally bedded packstone to grainstone in the top part. The top most part of lower Melmel succession characterize by coarse to very coarse grained, reddish brown to pink, poorly sorted, well lithified conglomeratic limestone.

The upper part of Melmel limestone is formed by thick succession of yellowish grey and fine laminated massively splitting thick oolitic packstone to grainstone. The base of the upper Melmel is inter-bedded with several levels of conglomeratic breccia horizon. It is fossiliferouse and the fossils are strongly aligned indicating an environment of high energy, possibly shallow marine. Moreover, the presence angular interclasts of quartz silt further support there proximity to the erosional surface.

Younger Deposits

It consists of eluvial, undifferentiated eluvial-alluvial as well as alluvial deposits. The eluvial deposit is grey to reddish brown colored, dominantly loamy with some fine sand, silt and clay soil, often-exhibiting well-developed soil horizon and it is

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most commonly developed above the limestone bed. Such deposit covered Wide area by southeast of Negele, around the airport. The undifferentiated eluvial and alluvial deposit are common along wet and marshy areas and it mainly consists of clay, silt and sand sized soil, with often sub rounded pebble and coble size rock fragments. Such deposit reported in the area by west of Negele along Hardot river. Alluvial deposits are common along flat vallies and intermittent river courses. It mainly composed of silt, fine sand and gravels, and it usually develops dark to light grey plane surface.

Geological structures are not abundant in the sedimentary terrain of the area. However, some structures, which are contemporaneouse and pencontemporaneouse to digenesis and lithification, were identified. The main structures present in the area are bedding, cross bedding slump folds. Bedding plain is very common in almost all Mesozoic sedimentary successions. The bedding plain have flat laying attitude, but locally slightly curved bedding surface which resemble convolent bedding supratneouse folding are occasionally observed. Generally, the sedimentary bedding tends to tilt 3-5^0 towards southeast. Cross bedding is observed on the Paleozoic clastic sandstone. Minor slump folds have been noted in the lower part of Jerder succession. These folds may have been resulted from submarine slumping and/or gravity-driving slides of unconsolidated sediments dawn the slope.

1-5-5-C-Basaltic Flows

Oligocene - Miocene age (Kazmin, 1979; Merla et. al., 1979; Mengesha et. Al., 1976) of Tertiary, basaltic flows are the only volcanic rocks available in the area. These rocks are in general basaltic flows with different proportion of mafic minerals especially olivine and pyroxene. The unit exposed as isolated small patch that distributed on late Proterozoic basement rock and on the limestone succession. There is good out crop of the basaltic unit along the main road to Negele near to Kersamele.

Fig3- The basaltic flow exposed along the road to Negele, a few Kilometers from Kersamele

The color of the rocks varies from dark grey to black and weathers to reddish brown, fine grained and aphyric to microporphritic with occasional presence of olivine, pyroxene and plagioclase phenocrysts. However, at some locality it

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turned in to reddish-brown soil. it often shows spheroidal weathering, in addition of slight surfacial weathering, not commonly vesicular, however locally minute vesicles were noted. No geological structure noted in the area on the unit.

1-5-6 Hydrogeology Of The District

The existence and amount of groundwater is governed by several factors such as the availability of formation that permit ground water storage as well as movement, and the hydrological condition of the area. Similarly, many variables control the quality of ground water to fit water quality for human consumption as well as domestic use. The type of formation in which the ground water stored and the liability of the ground water for artificial pollutant are among the factors that control the water quality.

Aquifer Classification of the Area

In this district, the existence and the storage of ground water is associated with the primary porosity of formations, originated from the nature of deposition in the sedimentary units, and secondary porosity developed in hard rocks as result of tectonic activity and by another surfacial as well as sub surfacial geological process. For better understanding of the aquifer system of the area, the different lithological units of the area shall be grouped in to three categories. These are:

- Those related with the basement rocks and with there associated intrusives.
- Those related with Jurassic-Cretaceous marine succession and Paleozoic basal clastics.
- Those related with tertiary volcanics and younger deposits.

The Aquifer System in Basement Rocks and Intrusives:

This category includes those aquifers of basement rocks of the gneissic terrain, the low-grade belts and syn- as well as post-orogenic granitoid intrusives. The lithological and textural feature of these rocks shows that naturally they are very massive with no primary porosity. These rocks only have secondary porosity developed as result of tectonism and other surfacial geological processes such as weathering.

During the early phases of deformation, both the high grade gneissic terrains as well as low-grade belts undergone compressional type of deformation and this deformation resulted in dominantly ductile deformation, possibly tightening, with

only few brittle deformation. As a result, the early deformation phases towards the improvement of the rocks porosity were low. The later phases of deformation in the basement rocks of the area include thrusting and shearing, and because of such deformation both ductile and brittle type of structures are formed. Mostly brittle deformations, such as fractures, are more interesting towards the increment of porosity of the rock.

However, the structures developed by last two deformational phases are localized in Wadera shear zone, thus only clustered by west side of the district. Moreover, the ductile nature of the faults and lineaments as well as there discontinuous nature makes the structures less important to serve as conduit or as storage media for ground water. Similarly, the intrusives are very massive in nature and differential affected by tectonism.

Beside the above fact, the climatic and hydrologic condition of the played it part not to weather the basement rocks and intrusives in to deep. For that, weathering of the rocks goes only few meters below the surface, not more than 20m. But from place to place the degree of weathering, on both basement rocks and intrusives, varies with compositional variation, lithology, local climatological factors as well as the location of the rock in the respect to the major and/or local geological structures.

Generally, it can be conclude that the Precambrian basement rocks and the associated intrusives are very poor in respect to ground water storage as well as permeability. Only localized shallow ground (<20) aquifer is developed in these terrains. The aquifer of these terrains are related with: weathering of the country rock, schistose planes, brittle fault plains, lithologic contact, fractures, joints developed on the intrusives due to deferential pressure. From general hydro geological point of view for prospective well sitting, they can be considered as poor or very poor terrains.

The fracturing and weathering degree of the rocks vary from type to type. For instance, in the un published hydro geological report of upper Dawa basin (Alebachew et.al.1997) it is reported that rocks of Adola and Wadera groups are more weathered than Algae group rocks. It also included in the report that Wadera meta-sandstone is better than Adola group in terms of productivity, since the fractured developed in the later unit refilled by weathered and altered Amphibolite. Syn tectonic granites are more of interest than post tectonic granites since the previous on is rather fractured and jointed than the other.

A number of boreholes and hand-dug wells have been constructed on the basement terrain. However, due to poor reporting and documentation about the wells' history, it is very difficult to differentiate those wells, which have fractured aquifer from those, which have over lay sedimentary aquifer. However, in most cases the wells located in the crystalline rocks have depth of not more than few

tens of meters (<50 as Negele military base well) the yield of wells the wells is in the range 0f O.1-1.5 l/sec. Some of the wells located along localized contacts of pre tectonic granites with other lithological units (Negele surrounding hand dug wells and bore holes) and joints of post tectonic granites (that of Hare Kelo & Bitata) and have rather good productivity. Perhaps, perennial artificial recharging of the aquifer played significant role in the improving of the wells productivity.

Aquifer System in Jurassic-Cretaceous Marine Succession and marine Paleozoic basal clastics:

The geological history of the area shows that the marine succession of the area hardly undergone secondary geological deformations as a result tracing long, open and inter connected geological structures on the marine succession is very difficult. The porosity of the marine succession rocks mainly related with inter-granular porosity, karst opening and free opening developed by alteration of limestone in to dolomite, dolomitization.

The upper part of the marine succession of the area, referred as Melmel limestone, consists of massively splitting thick Oolitic packstone-grain stone and developed insignificant porosity for ground water development in its' the upper part. The thickness of the layer extends up to 60m. the lower contact plane of the layer with under lain bed characterize by 5-10m conglomerate composed of carbonate boulders and reddish brown micrite mud cemented together by reddish micrite mud. The existence of such a thick conglomerate bed favored the existence of ground water in the Melmel at relatively shallow depth. However, the cementing material of the conglomerate layer depreciated the available effective porosity of the well. As a result wells located Melmel unit have moderate to good productivity and the depth of the aquifer is shallow as compare with the other marine succession terrains. This fact perhaps, can be further justified by the existence of shallow boreholes in Siminto (Siminto well: depth 69m) area and around the airport (Fulo well:depth-59m). The lower part of Melmel succession, below the conglomeratic layer, is not significant from hydro geological point of view since it composed of thick alternate bed of psckstone-wackstone-grainestone. In fact, primary effective porosity of the layers is poor; however, the secondary may improve the hydraulic property of the layers and it mainly depends on the degree of karst formation developed on the layers. This fact, perhaps, once again may be justified by insignificant increment in the productivity of the wells those have deeper depth (>100m, <150m : Haro kile bore hole:depth=121m).

The other major marine succession is Jerder limestone; characterize by mudstones, fossil reef limestone, wackstone as well as shale in the lower part (. thickness of 80m), and characterize by dolomitic wackstone pep petal grainstone, travertine, sandstone and conglomerate in the upper part. The overall

thickness of Jerder limestone may reach up to 200m. The porosity in Jerder succession can be related with; the primary porosity of the sandstone-conglomeratic beds in the upper part, the porosity developed by extra openings as result of alteration of limestone in to dolomite and karst developed in different beds of the succession. Some very deep boreholes had sunk in the eastern part of the district and these wells are believed to penetrate dawn below Melmel in to Jerder succession. However, in most cases well lithological logging was not possible because of the circulation loss, thus the hydraulic characters of beds poorly understood. Nevertheless, from circulation loss it can be inferred the existence of open media formed either by tectonism or by karst formation. In most cases this openings are not saturated, since the preliminary pumping test results show not high productivity. This may be happened because of the blanketing effect of black-shale, which arbitrarily used as separation layer for Jerder from Melmel succession.

Paleozoic basal clastics of the area consist of cross-bedded sandstone. This sandstone layer is very porous and wells located along the bed have moderate-high productivity in areas where recharging agent for the aquifer is good such as that of Gobicha. It is very localized and controlled by paleo topography, thus the thickness may vary from a few ten of centimeters up to few tens of meters.

Aquifer System in Tertiary Volcanics and Younger Deposits

Tertiary volcanics are very small localized and not extensive in aerial coverage. Only little known about the hydraulic character of this formation since only very few exploratory and functional boreholes were sunk on this unit. The borehole drilled, for military base, on this unit show that the unit is very thick, and the aquifer is mainly composed of fractured and weathered basalt. The pumping test result document reported that the well yields 1.5 lit/sec. Thus, it can be inferred that the aquifer system in this unit is mainly fracture aquifer with low permeability at moderate depth<100m.

The younger deposit includes eluvial, undifferentiated eluvial-alluvial as well as alluvial deposits. The eluvial deposits are in situ formed grey to reddish brown colored, dominantly loamy with some fine sand, silt and clay soil, often-exhibiting well-developed soil horizon and it is most commonly developed above the limestone bed. Only retain water as soil moisture for short period time after wet seasons. The eluvium deposits are not such important for ground water development, but there role in the hydrological parameters is high as such infiltration and run of calculation. The undifferentiated eluvial and alluvial deposit are common along wet and marshy areas and it mainly consists of clay, silt and sand sized soil, with often sub rounded pebble and coble size rock fragments. Such deposit reported in the area by west of Negele along Hardot river. These deposits are very important for ground water development at very shallow depth in all terrains, especially in granitic and high-grade crystalline basement rock terrains. The thickness of such deposits may vary from few meters up to tens of

meters and there productivity mainly depends up on the proportion of sand-gravel amount with respect to proportion of clay-silt. Most of very shallow boreholes and almost all hand-dug wells are located on these deposits. The undifferentiated nature of the layers makes the water holding capacity to vary within limited course of traverse, thus the exploration work mainly depends on the surfacial artificial such as traditional wells, as well as natural, such as seepages, contact springs e.t.c. features. Alluvial deposits are common along flat valleys and intermittent river courses. It mainly composed of silt, fine sand and gravels, and it usually develops dark to light grey plane surface.

Beside the geological factors, hydrological parameters are also very important factors for the existence of ground water. The hydrological factors control the existence of the ground water though the rate of ground water rechargibility. In addition, hydrological measurements are some how very important to qualitatively characterize the hydraulic property of the rocks where seepages and springs are existed, and where the under ground layering little known.

However, lack of previous work on the infiltration, runoff, and evapo-transpiration rate as well as limitation on the metrological recording stations make difficult the estimation of the proportion of the precipitation that used for ground water recharging annually, assuming that the rainfall is the main recharging agent.

As mentioned rainfall is the main agent in recharging the aquifers of the area since there such a big water body in the area except at the border of the district (river Awata, Dawa and Genale). Perhaps these rivers, except Genale play insignificant role for recharging the aquifer of the area. The water from the rain go to aquifer through fractures where the bedrock covered by thinner eluvial deposits, through bedding planes, joints, schistosity etc. For shallow ground aquifers as that of younger deposits direct infiltration seems possible.

Beside, rainfall artificial perennial water bodies such as big ponds are thought to be recharging agene for shallow ground aquifers in the lower respective lower courses. For this the hand-dug wells located at down streamside of Legebora and Raro hand dug well can be taken as an example. Oral information from the respective community and not properly documented report about the Negele hand dug wells revel that the static water levels as well the productivity of the wells never been as present before construction of the dam. Similarly, Raro hand dug well located on sand-silt deposit just behind the pond embankment and there where no hand dug well before the construction of the pond.

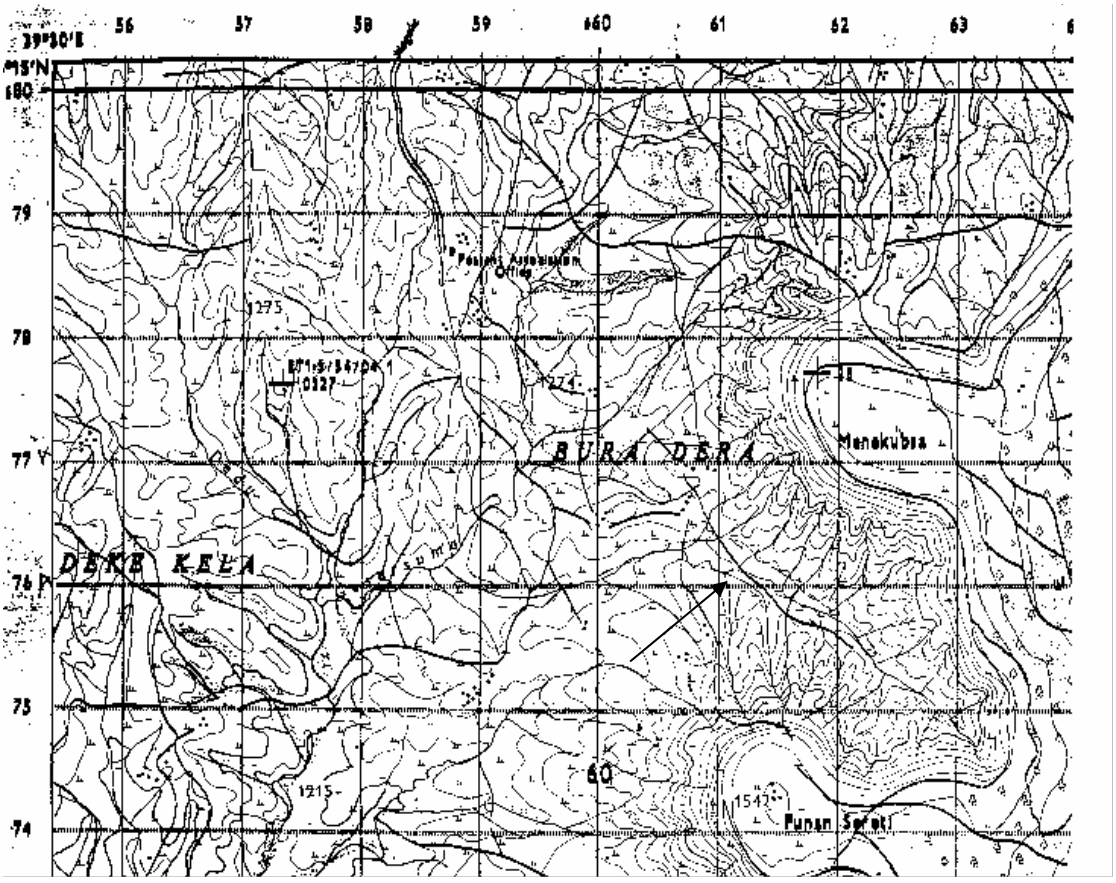
SELECTED AREAS

2- BURA DHERA

2-1 Location

BuraDhera is located by SSW of Negele town. The place where the study carried out found in eastern part of BuraDhera at place called Reketu. It is accessible by dry weather road from Negele to Bura-Dera via Gobicha and it fars 20 Kms from Negele.

Location Map of Bura Dhera
Ethiopian Mapping Authority
1: 50,000 Topographic Map
Sheet No 0539 D3
Siminto sheet, 1989



2-2 Geology and Hydrogeology

Two distinctive physiographic features are prominent in the area; these are the eastern cliff forming sedimentary platform and the western undulating landform. The eastern cliff formed as result of sedimentary succession summit up to 1460 m.a.s.l. and it is flat at the top that slightly dips toward southeast.

Undulating landforms in association with isolated small cons are the prominent landform in the western portion of the study area. The mean altitude fall below 1300m a.s.l. and the general dipping direction change to SSW. In general, there is high relief as we go from west to east and the relief could reach up 300m.

No perennial surfacial water body exists in the area. Concerning drainage, the eastern margin of the study area characterize by flat plain land with no developed drainage line while the western margin characterize by well-developed drainage line that formed as result of intermittent watercourses. The drainage pattern in this part of the area is dendritic or semi dendritic type that seems slightly controlled by geo-structures.

In the area two rock types area identified and these rock types are the basement schist rock and marine sedimentary unit. The features and local setting of the two units presented below.

The schist rock, which belongs Adola group of basement rock and it consists of actinolite with subordinate actinolite-quartz epidot schist. Locally it is weathered, fractured and developed red brown eluvial material at the top. This unit exposed at the intermittent stream channels and at trail cuts as well as hillsides. It formed step slop hill below the layer of the top lain marine calcareous unit. Its contact with the calcareous unit is very distinctive, thin layer of conglomerate.

The marine calcareous comprises limestone succession with inter-bedded marl. The unit is very prominent in the eastern margin, North eastern, southeastern as well as central southern part of the study area and it is volumetrically the major-one in the area. It formed plat form on top with cliff edges on the western side and the plat form slightly tilt towards to southeast.

It appears as the top most layer above altitude of 1400m and its contact with the bottom layer is easily identifiable from the aerial photographs and/or satellite images*. The rock lithology in the unit varies from the top to the bottom. In the top part it mainly consists of layers of limestone with inter bedded very thin shale layers and it is white colored, massive, slightly affected by weathering. Regionally, this succession grouped in to Jerder limestone succession

*NNW- north north west
**NW- north of east

In the study area, the schist unit bounded by syn tectonic granite by west side. Alluvial sediment composed of silt sand and gravel is found in side the schist unit along the intermittent stream channels. The thickness of the sediment material ranges from few centimeters up to tens of meters.

Fig4- adapted from satellite image, composite band of 1,3,7

Ground water storage and movement mainly governed by the existing Geology and hydrological condition of the area. The transmissibility of ground water in hard rock directly related with the secondary porosity developed on the rock as result of fracturing and weathering and the productivity of the aquifer in such rocks depend on degree of fracturing and weathering as well as other hydrological parameters. In case of alluvial deposit, the productivity is mainly related with inter-granular porosity, and the effective inter-granular porosity could be affected by the amount of silt material that can fill the pore spaces.

Springs, seepages and traditional hand dug wells are among the indicators for the existence of shallow ground water. In our study area, there are a number of traditional hand dug wells and the wells are located seriously along the streamline. The depth of the wells vary from few meters i.e. <5m up to just a little bit deeper than 10m. The static water of the wells also varies with local topographic variation. Water bearing layer for the wells is mostly the alluvial deposit of sand, found along the stream lines.

*NNW- north north west
**NW- north of east

In general, the existence of fractured rocks and alluvial-deposited materials in the area favor ground water accumulation especially along streamlines. The main aquifer system of the area expected to be either silt-sand layer or fractured basement rock. Although the catchment's area is not wide, it expected to be stored good amount of water in sand-silt layer as well as in the fractured basement rocks of the area.

2-3 Geophysical survey

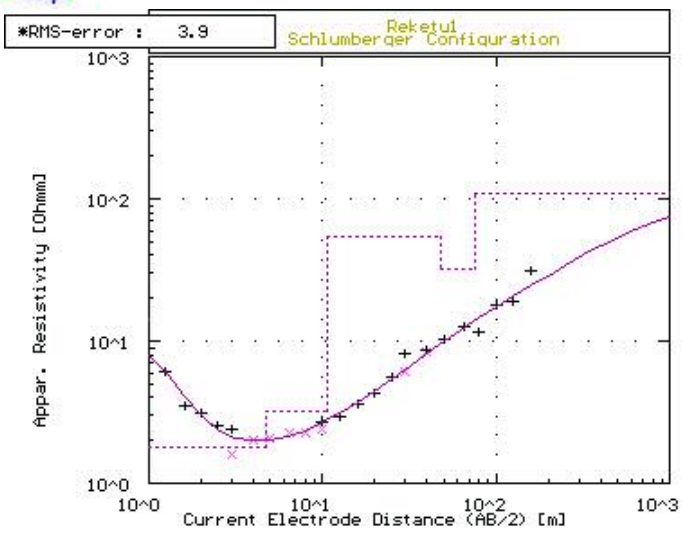
The geophysical survey conducted in the area targeted on the understanding of the shallow under ground layer stratification and thickness with respect to electrical property of the layers as well as its lateral variation of layers. Thus randomly distributed vertical electrical soundings were carried out.

Totally three soundings carried out in the area. The center of first VES was at 5.21577^0 north and 39.54787^o east. The azimuz of the first sounding is nearly east west and the spreading finalized at AB separation of 320m. The second VES was conducted by centering at 5.21260^0 north and 39.5540^0 east with azimuth of $N60^0E$. The final spreading ceased at 500m AB separations and it followed the major streamline of the area. The last, third, VES also accomplished by spreading the electrodes nearly parallel to the second VES. The geographic coordinate of VES-3 center were 5.212190 north and 39.55200^0 east and like to the second VES the final AB separation was 500m.

Data Analysis

HH, HA and HA type curve obtained from the respective three electrical soundings. Regardless of the position of the VES centers and similarity of type curves, different geo-electrical model formulated. See the obtained geo-elctrical models in the following curves.

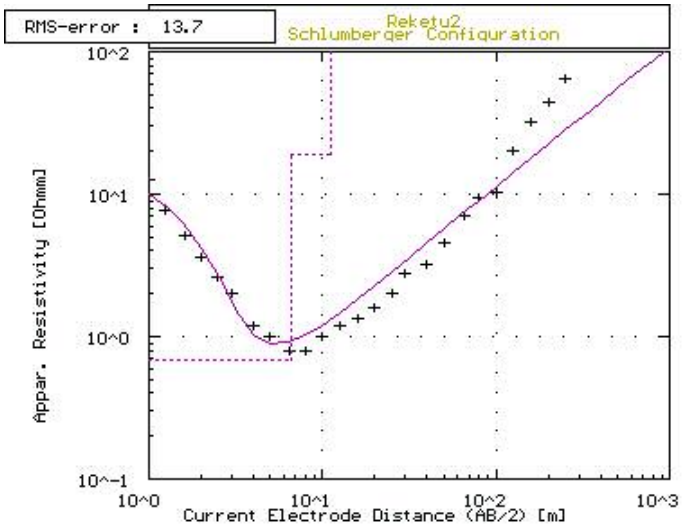
*NNW- north north west
**NW- north of east



No	Res	Thick	Depth
1	14.3	0.5	0.5
2	1.8	4.2	4.7
3	3.2	5.9	10.6
4	54.1	37.0	47.6
5	32.2	28.4	76.0
6	110.3	-.-	-.-

* RMS on smoothed data

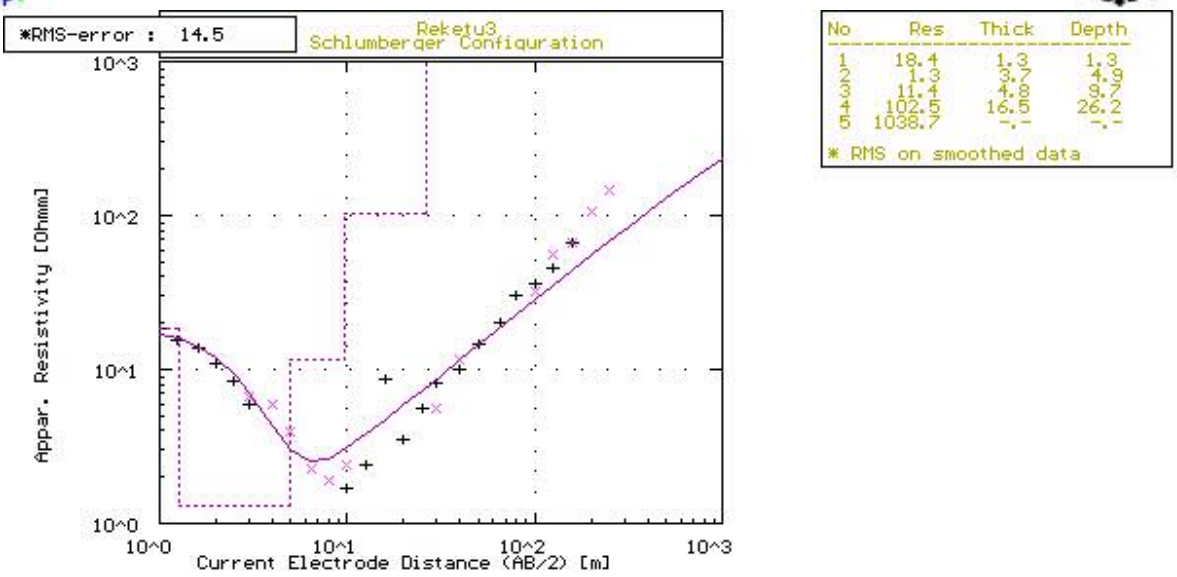
The first VES conducted parallel to the road, along the stream.



No	Res	Thick	Depth
1	12.9	0.8	0.8
2	0.7	5.8	6.6
3	19.2	4.7	11.3
4	292.2	44.3	55.5
5	3389.1	-.-	-.-

It was done by spreading nearly E-W

*NNW- north north west
**NW- north of east



Perpendicular VES-2

The first VES resulted in six geo electrical layers on which the first successive three layers are more conductive. The fourth and the first layers are a bit more resistive and the bottom of the fifth layer extends up to 76m from the top of fourth layer i.e. 10.6m. The bed -rock of the area represent by moderately high resistivity value below depth of 76m.

The other two sounding are very similar in terms of geo-electrical layering and depth. On both curves, the top three conductive layers were been represented by very low resistivity values and the bedrock also shown by high resistivity value below depth of 55 meters. Even though both sounding shows the major geo-electrical layering trend, it should not been considered as perfect data to determine the overall layer parameter because of the following factors.

- As it were observed during data acquisition the recorded resistivity values are very low that is unlikely to be happen in specified geological setting
- Noisy field data recorded are significant in number, so it possibly affect the final geo-electrical model of the area.

In order to improve the quality of the data the row data smoothed manually and interpreted using Orellana- Mooney master curves and recalculated using resist software.

Interpretation

The interpretation of geo-electrical layer models in to litholgical layer models has been done mainly based on observed lithological horizon observed at the hand dug wells and the local geological set up the area.

*NNW- north north west
**NW- north of east

Therefore, the first two layers of VES –1 possibly represent the alluvial deposit of sandy-silt, which extends up to 4-5m. The third geo-electrical layer shows the fractured basement rock that saturated with water and it extends up to depth of 10.6m. The layer up to 76m depths shown by slightly higher resistivity value and it is possibly fractured and wet gneissic rock with variable weathering degree.

Rather than quantitative interpretation, it is preferable to make qualitative interpretation for VES –2 and VES-3 since the curves a bit divert from the ideal vertical sounding curves. But in both cases HA type curves are formulated and it means that for shallower depth the resistivity value drops. However; with increasing depth the resistivity value, increase sharply. As shown on both curves the conductive media goes down up to around 12m and it is consistent with the feature that can be seen from the horizon at hand-dug wells. The interpretation of geo-electrical layers in to lithological layers is summarized in the following table.

Resistivity (ohm-m)	Depth(m)		Possible Lithology
	From	To	
14.3	0	0.5	Clay,Silty with sand
1.6	0.5	4.7	
3.2	4.7	10.9	Very Highly weathered & Fractured basement rock with fine silt could be water
54.1	10.9	47.5	Fractured basement Rock, Possibly bearing water bearing
32.2	47.5	76.0	
110.3	76	-	Bed rock

Table-1 VES-1

Resistivity (ohm-m)	Depth(m)		Possible Lithology
	From	To	
12.9	0	0.8	Clay, silt with sand
0.7	0.8	6.6	
19.2	6.6	11	Sand or Fractured Basement rock possibly Water Bearing
292.2	11	55.5	Hardly Fractured Basement rock
3389.1	55.5	-	Bed rock

Table-2 VES-2

*NNW- north north west
**NW- north of east

Resistivity (ohm-m)	Depth(m)		Possible Lithology
	From	To	
17.6	0	1.2	Clay, silt with sand
1.7	1.2	7.1	
30.4	7.1	11.4	Sand or Fractured Basement rock possibly Water Bearing
215.4	11.4	41.4	Hardly Fractured Basement rock
10068.1	41.4	-	Bed rock

Table-3 VES-3

From the VES curves and already excavated hand dug wells, the characteristic nature of the area favors the existence shallow depth ground water. The depth of the aquifer and its thickness mainly related with the underlain sand unit that could be up to 7m thick and fractured basement rock underneath.

Thus excavating a well in the area is very recommendable especially at the center of VES-two. The depth of the well shall been determined by the lithological log observation during well digging.

2-4 Existing Water Source and Quality

The water sources in the area during dry season are the traditionally excavated hand dug wells. All in all the wells are 12 in number and serve the community for both domestic consumption as well as watering domestic animals. People use to excavate small pits to collect water during wet season and they use it for short time after the end of wet season.

As seen during field survey the water from the hand-dug wells physically look un-potable. It is highly turbid and full of aquatic flora and fauna. water sampled from two wells and tested for some water quality parameters.

Sample no	Name of the well	Conductivity µs	Cl^-	No_2	Ph
1	-	4070	300	0.4	7.5
2	BoruLiben	2039	180	1.0	7.5

Table-4

*NNW- north north west
**NW- north of east

3- Area By North of Harekelo

3-1- Location

The area includes the prospective areas from Harekelo towards north up the boundary of the district. The average distance of the area from Negele is around 50km towards north. In UTM geographic coordinate system the place demarcated by:

533000m to 543000m east
613000m to 630000m north

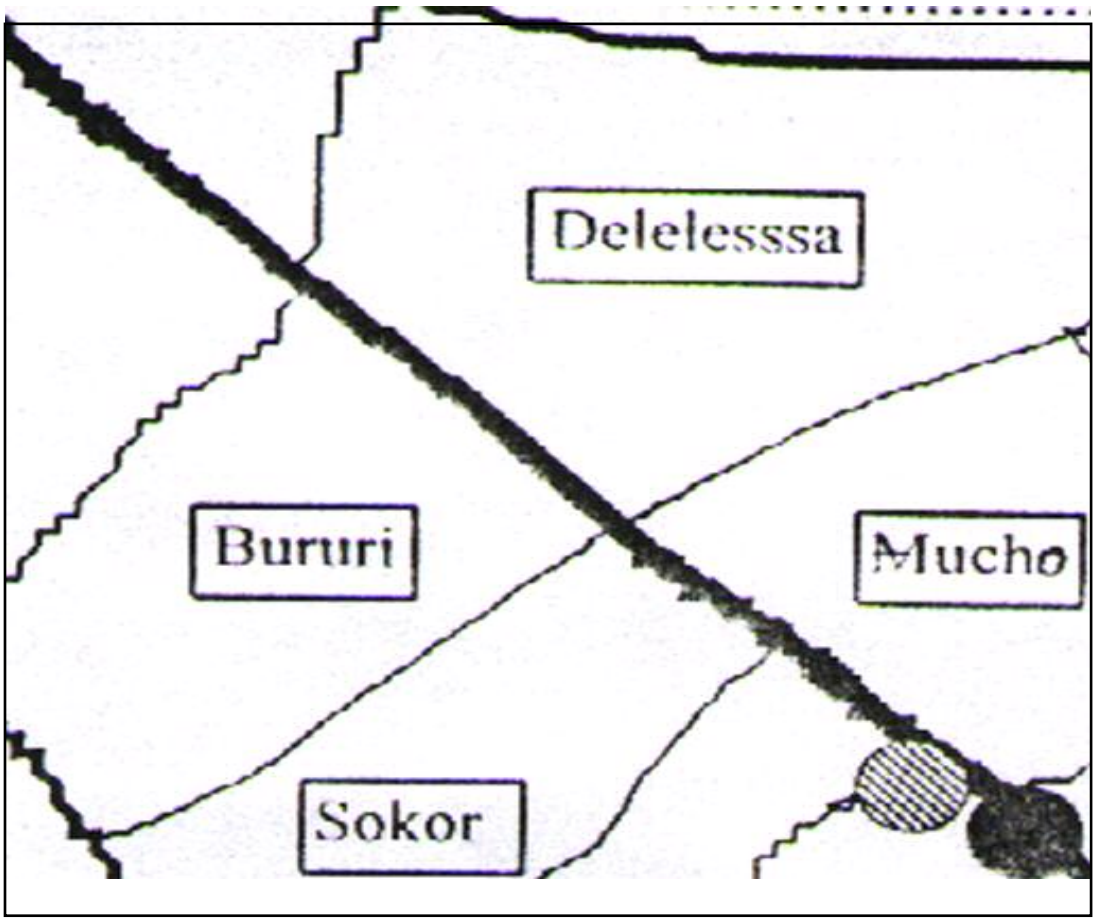


Fig5- location Map, Sketch not on true scale

*NNW- north north west
**NW- north of east

3-2 Geology of the area

Undulating land forms with North-south aligned rides and depressions are common in the area, and characterize by high relief variation. The mean elevation of the area is around 1600m a.s.l.

Two types of rock units are prominent in the area. The first rock type that exists in the area is Algea gneiss. It consists of biotite-hornbelnde gneiss with subordinate biotite, hornblende-biotite, quartzo-feldspatic gneiss, biotite, deformed and/or undeformed biotite granite as well as migmatite. In addition to the gneiss rocks, talc-tremolite schist occurs as minor lenses. It extensively exposed as a wide belt, running from north to south in the central northern part of the district and it exposed along the valley of intermittent streams such as Sokora.

The other rock unit that major in the area is Awata gneiss constituted mainly of biotite-plagioclase-microcline-quartz mylonite with presence of migmatized hornblende-biotite gneiss and hornblende gneiss. It exposed in the north western part of the district in side Wadera shear zone. This unit is locally undergone surfacial weathering in the top part.

In addition, syntectonic Granites are abundant in association with the above mentioned two major rock types. The syntectonic granites are more prominent in the area around Harekelo village. It is hardly weathered and fractured.

It is also possible to see alluvial deposited materials along small intermittent streams in the area and these deposits are much more important than the other major rock units of the area. Since the major rock units of the area developed thin weathered part in top most part and the rocks are naturally hard mean that they don't have primary porosity.

The transmissibility of ground water in hard rock directly related with the secondary porosity developed on the rock as result of fracturing and weathering and the productivity of the aquifer in such rocks depend on degree of fracturing and weathering as well as other hydrological parameters. In case of alluvial deposit, the transmissibility is mainly related with inter-granular porosity, and the effective inter-granular porosity could be affected by the amount of silt material that can fill the pore spaces.

There are a number of hand-dug wells in the area excavated traditionally by the communities, and most of the traditional wells are located on the bank of streams where the deposited material is thick. This is one of the indications regarding the shallow ground condition of the area.

*NNW- north north west
**NW- north of east

The above facts lead us to focus on the places where thick deposited materials can exist for well sitting and as result two places are identified. The places are called as Mucho and Dolcha: Much found by North of Harekelo and the site selected for further study lay along the intermittent stream line of Dendema.

Dolcha is found in SikoBururi Pa, by northeast of Harekelo. The site selected for water intervention lay along MelkaFura stream line. Thick alluvial deposited material is observable along the stream channel section and this indicates that there is high possibility of getting shallow ground water.

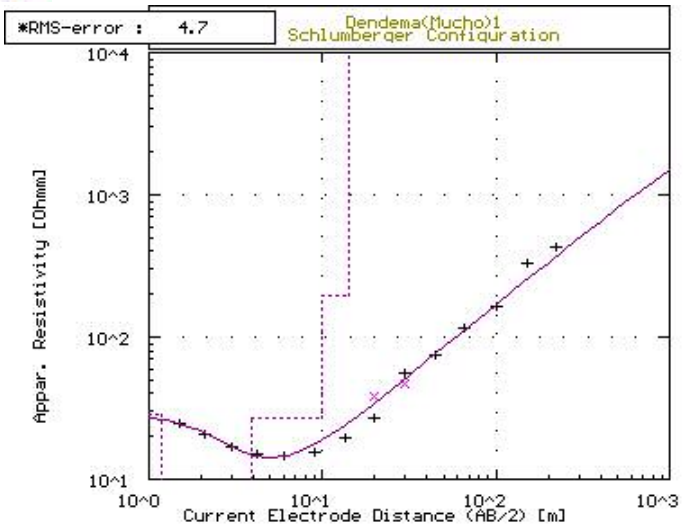
3-2-Geophysical survey

Geophysical survey was carried out after the hydro-geological observation in the above mentioned areas. The survey was done only in Mucho, because the topographic condition of Dolcha doesn't permit the geophysical survey.

Two vertical electrical sounding conducted along the local steam line in Dendema area. The center of the first sounding is 541167m east and 619863m north with azimuth of 53^0NE. The second VES centered at 542422m east and 620016m north. The azimuth is similar to the first and the electrodes spread parallel to the streamline.

data analysis

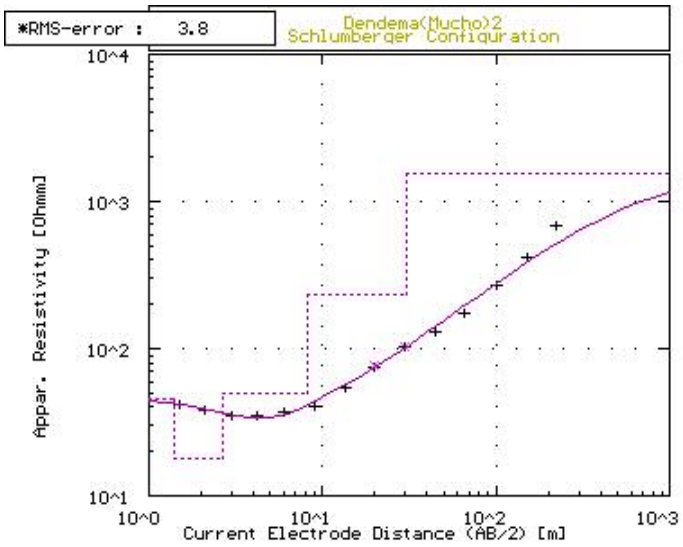
Mucho-Five layers geo-electrical model was set from the two vertical electrical sounding conducted in Mucho. Both vertical electrical soundings are resulted in HAA type ideal curve with similar trend of layering with respect to depth and resistivity. The following two curves are obtained from VES-1 and VES-2 respectively.



No	Res	Thick	Depth
1	28.8	1.2	1.2
2	9.0	2.7	3.9
3	26.9	6.0	9.8
4	195.0	4.4	14.2
5	12043.5	-.-	-.-

* RMS on smoothed data

Mucho VES-one Parallel to the stream



No	Res	Thick	Depth
1	45.3	1.4	1.4
2	17.8	1.3	2.6
3	50.0	5.4	8.1
4	229.7	22.4	30.5
5	1543.9	-.-	-.-

* RMS on smoothed data

Mucho VES two done dawn stream to VES-one, along the same stream line

Interpretation

The interpretation of geo-electrical layer models in to lithological layer models has been done mainly based on lithological horizon observed at the hand dug wells and the local geological set up the area.

The first two layers of VES –1 possibly represent the alluvial deposit of sandy-silt, which extends up to 4m. The third geo-electrical layer shows possibly sand saturated with water and it extends up to depth of 9.8m. The layer up to 14.2m depths shown by slightly higher resistivity value and it is possibly fractured and wet gneissic rock with variable weathering degree and after the depth below it the bed rock shown by very high resistivity value.

The first two layers of VES-2 possibly represent clay soil, which extends up to 2.6m. The third geo-electrical layer shows possibly sand saturated with water and it extends up to depth of 8.1m. Unlike to the in the first VES, in the second VES the fourth layer, that is possibly fractured rock, extends un to the depth of 30.5m.

The summery of the interpretation presented in the following table.

VES-1			
Resistivity (ohm-m)	Depth(m)		Possible Lithology
	From	To	
28.8	0	1.2	Clay, Silt with sand
3	1.2	3.9	
26.9	3.9	9.8	Sand, possibly water bearing
195	9.8	14.2	Fractured basement Rock
12043	14.2	-	Bed rock
VES-2			
45.3	0	1.4	Clay, silt with sand
17.9	1.4	2.6	
50	2.6	8.1	Sand or Fractured Basement rock possibly Water Bearing
229.7	8.1	30.5	Hardly Fractured Basement rock
1543.9	30.5	-	Bed rock

Table-5

UTM – Universal traverse Marketers
VES- Vertical electrical sounding

The vertical electrical sounding survey shows the existence of conductive layer up to the depth of 10m. Thus it is recommendable to excavate shallow depth hole in the area for the construction of water well. Especially the place, where the first sounding centered, is more favorable than the second sounding center.

UTM – Universal traverse Marketers
VES- Vertical electrical sounding

4- The Area from North of Negele Town up to the road to Genale

4-1 Location

The place incorporated in the area those places that appear in between Negele town and the main road to Genale. It Include places like Kobadi, Ardabururi, GofaAmbo, Afleta Bitata and e.t.c. In UTM geographic coordinate system the places are incorporated between 556000-570000m east and 590000-608000m north.

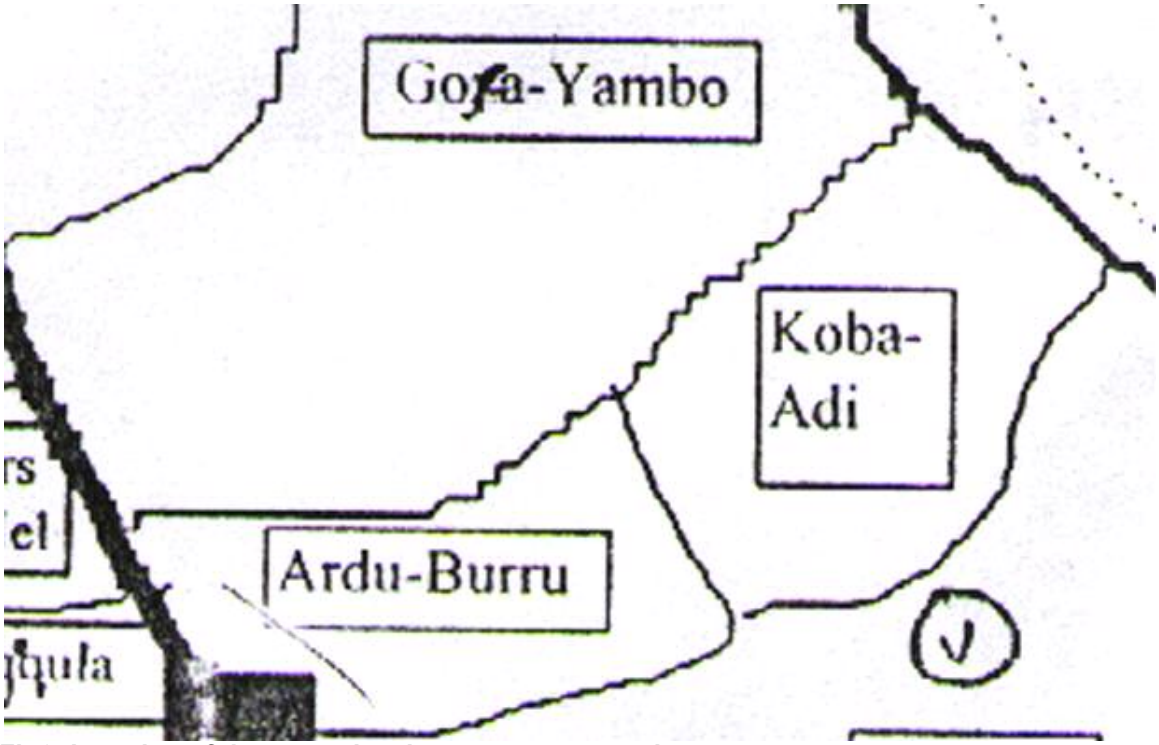


Fig6- Location of the area, sketch not on to true scale

4-2 Geology of the area

Undulating land forms with isolated granite domes are common in the area. The mean elevation of the area is around 1400m a.s.l. locally the drainage pattern in the area is semi dendritic but towards Northwest it become more of structural controlled.

Four types of rock units are prominent in the area. The first rock type appears in the area is Awata gneiss constituted mainly of biotite-plagioclase-microcline-quartz mylonite with presence of migmatized hornblende-biotite gneiss and

UTM – Universal traverse Marketers
VES- Vertical electrical sounding

hornblende gneiss. This unit locally has undergone surfacial weathering in the top part and developed reddish eluvium on top. It extensively covered the western part of the area along the road to Addis Abeba.

Adola group that consists of talc schist, chlorite-tremolite-talc schist, chlorite-actinolite schist, actinolite schist exist in the area as a lance. Syntectonic Granites are the most prominent rock types in the area. It is locally fractured and weathered, and it formed undulating land forms.

Post tectonic biotite granite also exists in the area by forming dome like structures scattered in the other units. This unit is not weathered, it is fractured. The unit becomes very prominent further in the northern part. Similarly small isolated cones of basaltic flows also exist in the area.

It is also possible to see alluvial deposits and close basin deposits along small intermittent streams in the area and these deposits are much more important than the other major rock units of the area. Since the major rock units of the area developed thin weathered part in top most part and the rocks are naturally hard mean that they don't have primary porosity.

The transmissibility of ground water in hard rock directly related with the secondary porosity developed on the rock as result of fracturing and weathering and the productivity of the aquifer in such rocks depend on degree of fracturing and weathering as well as other hydrological parameters. In case of alluvial deposit, the transmissibility is mainly related with inter-granular porosity, and the effective inter-granular porosity could be affected by the amount of silt material that can fill the pore spaces.

There are a number of hand-dug wells in the area excavated traditionally by the communities, and most of the traditional wells are located on the bank of streams where the deposited material is thick. In addition to hand dug wells there are a few bore holes in the surrounding of Negele town. The depths of the boreholes are in the range between 40m and 120m. The main aquifer of the boreholes is fractured basement rock.

On the basis of the mentioned hydro geological consideration the following sites are selected for further geophysical study.

1. Haro
2. Arda Bururi
3. Bitata Bura
4. Shishu
5. Wefe

4-2-Geophysical survey

Data Acquisition

Geophysical survey was carried out after the hydro-geological observation in the above mentioned areas. The survey was done in Haro, Arda Bururi, Bitata Bura, and Shishu.

Haro-Three surveys were carried out in Haro. The first VES centered at 564622m east and 591279m north and the electrode spreading azimuth was $N280^0$. The second survey was centered at 564721m east and 591313m north, the electrode spreading azimuth was east-west. The geographic coordinates of the third sounding center was 564844m east, 591321m north and the azimuth of the spreading was the same with that of VES two.

Arda Bururi-Two electrical soundings were carried out in Arda Bururi. Both of the soundings are carried out along the stream so the azimuth of the electrode spreading was the same i.e. $N65^o$. The center of the first sounding was at 564831m east and 597518m north while the second sounding centered at 564851m east and 597564m north.

Bitata Bura- A total of 10 vertical electrical soundings carried out in Bitata Bura area. The first two was done before the excavation of exploratory hole. The first sounding was centered at 607433m east and 559680m north with spreading direction of nearly NS. The other sounding is centered at 559703m east and 607364 m north with azimuth of 30^0 NW.

Well excavation work had been taken in Bitata Bura in a place a few tens of meters away from VES two center. However, the observed lithological layering differ from the established model, obtained from vertical electrical sounding. Moreover, no water-bearing layer encountered up to 7m. Thus, for better understanding of the area, further systematic resistivity survey suggested and the survey carried out accordingly.

Position	VES-3	VES-4	VES-5	VES-6	VES-7	VES-8	VES-9	VES-10
EAST	559735	559769	559798	559823	559804	559782	559835	559749
NORTH	607645	607644	607624	607642	607605	607599	607602	607595

Table-6

Shishu-five soundings were conducted. The first sounding was centered at 614778m North and 556227m east. The cable was spread perpendicular to the main stream line with azimuth of $N30^0$. the second was done by spreading the electrode along the main streamline. The azimuth of the second sounding is $N20^0$ and the geographic coordinate of the center is 556185m east and 614819m

UTM – Universal traverse Marketers
VES- Vertical electrical sounding

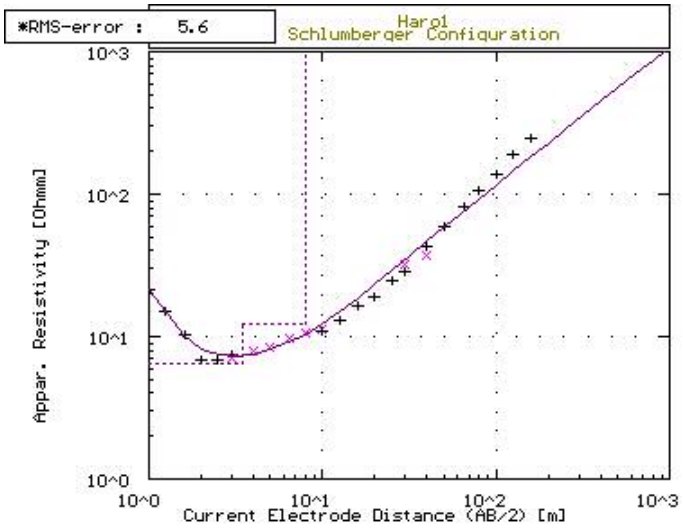
north. Like wise, the other surveys were conducted along the mainstream line with the coordinate of the centers shown on the following table.

Position	VES-1	VES-2	VES-3	VES-4	VES-5
NORTH	614778	614819	615044	614983	615145
EAST	556227	556185	556160	556149	556181

Table-7

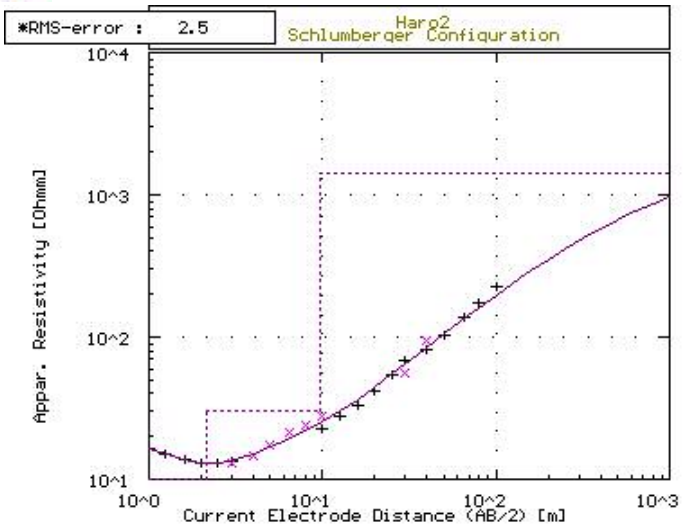
Data Analysis

Haro-HA, H and HA type curves are obtained from the respective three soundings in Haro.



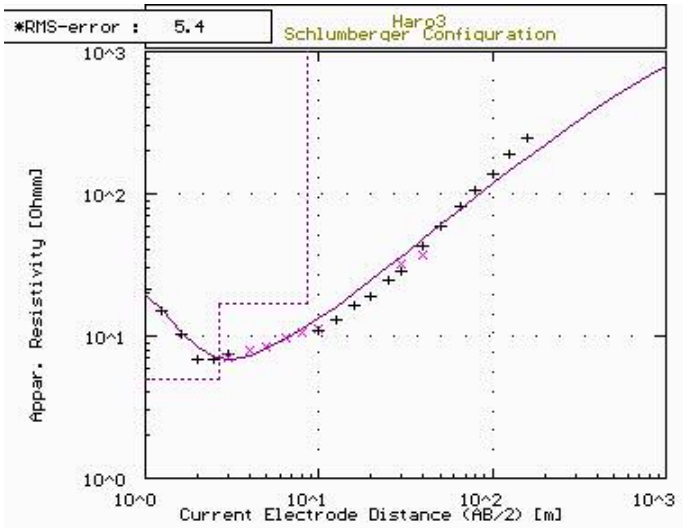
No	Res	Thick	Depth
1	60.5	0.4	0.4
2	6.4	3.1	3.4
3	12.2	4.6	8.0
4	13220.1	-.-	-.-

* RMS on smoothed data



No	Res	Thick	Depth
1	21.3	0.5	0.5
2	10.1	1.7	2.2
3	30.1	7.6	9.8
4	1428.2	-.-	-.-

* RMS on smoothed data

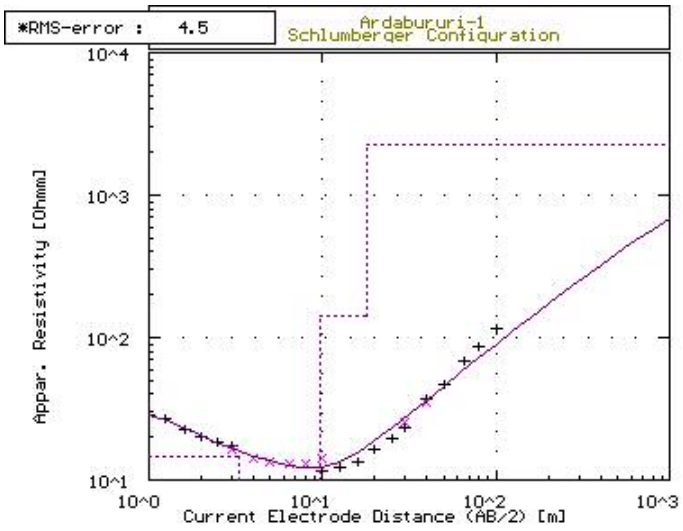


No	Res	Thick	Depth
1	34.0	0.5	0.5
2	5.0	2.2	2.7
3	16.8	6.0	8.6
4	1898.3	-.-	-.-

* RMS on smoothed data

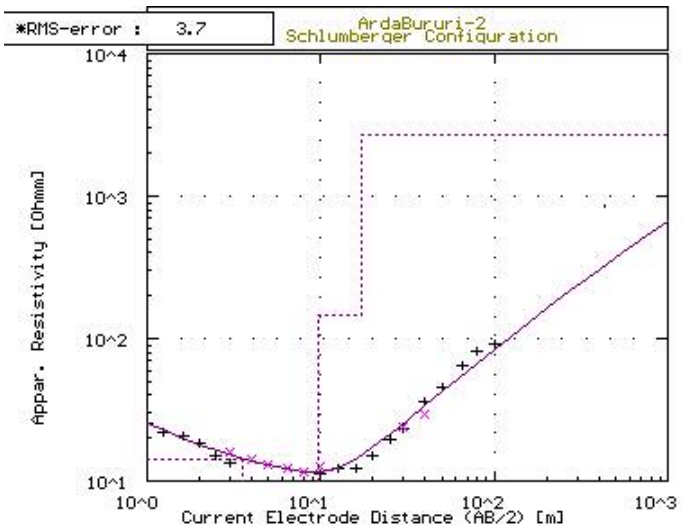
UTM – Universal traverse Marketers
VES- Vertical electrical sounding

Arda Bururi- QHA type curve obtained from the two surveys carried out in Arda Bururi.



No	Res	Thick	Depth
1	34.0	0.7	0.7
2	14.8	2.6	3.3
3	7.8	6.4	9.7
4	142.7	8.2	17.9
5	2259.2	-.-	-.-

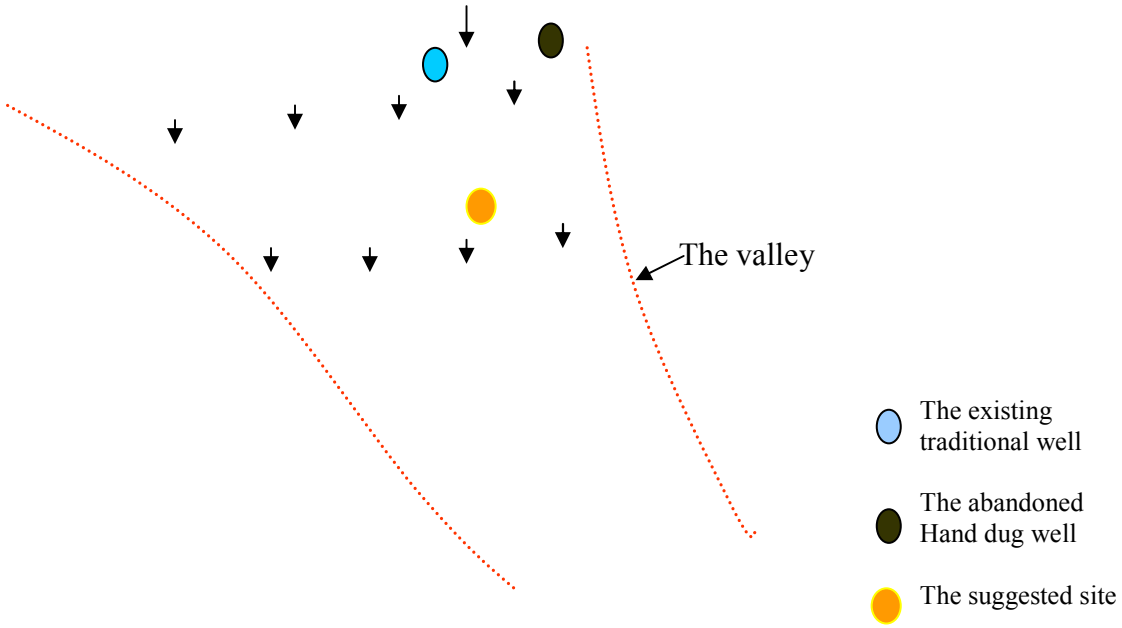
* RMS on smoothed data

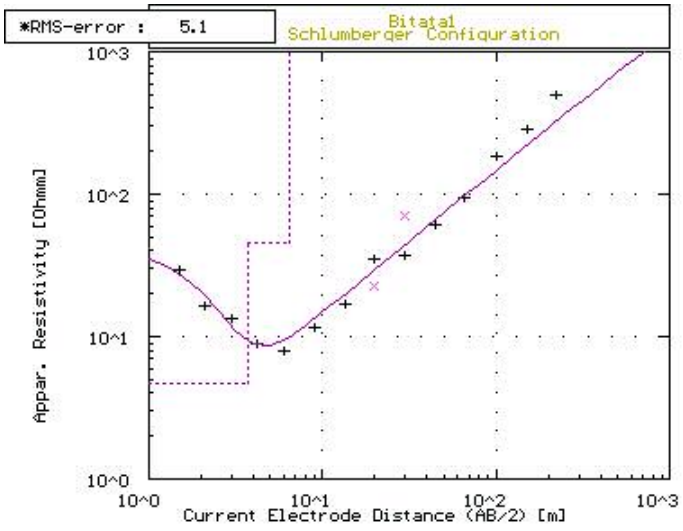


No	Res	Thick	Depth
1	31.3	0.6	0.6
2	14.1	2.9	3.5
3	6.9	6.2	9.7
4	147.5	7.4	17.1
5	2670.3	-.-	-.-

* RMS on smoothed data

Bitata Bura- The curve obtained from the respective ten soundings in Bitata Bura Area. The position of the soundings is shown in the following sketches



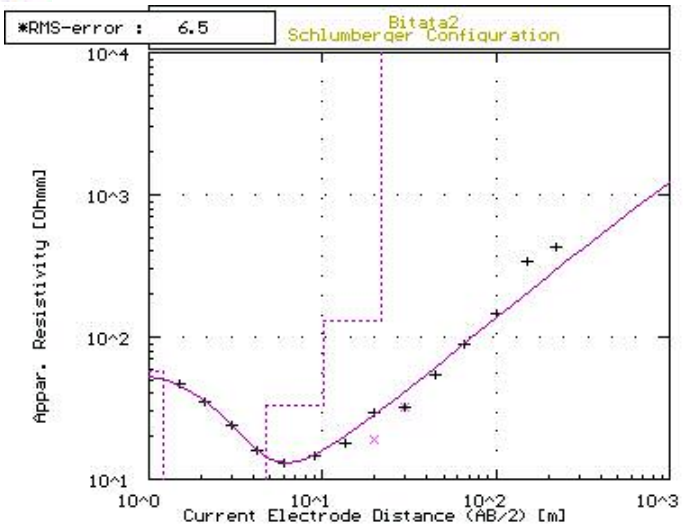


No	Res	Thick	Depth
1	41.1	0.9	0.9
2	4.7	2.8	3.7
3	45.5	2.7	6.4
4	18394.4	-.-	-.-

* RMS on smoothed data

VES-1 in Bitata Bura area

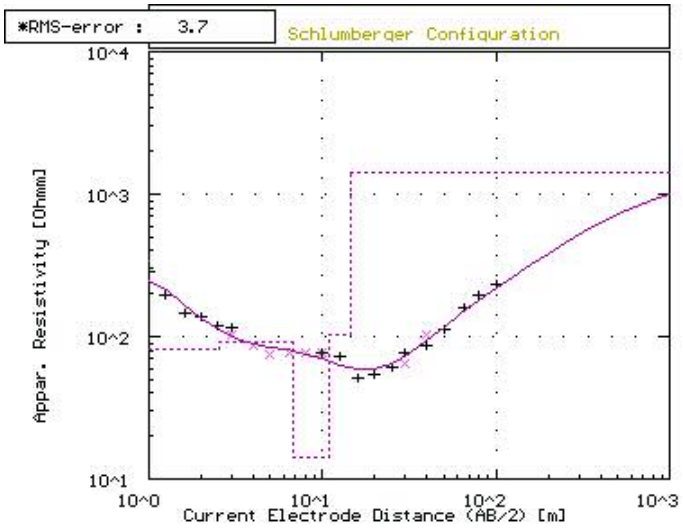
UTM – Universal traverse Marketers
VES- Vertical electrical sounding



No	Res	Thick	Depth
1	56.7	1.2	1.2
2	7.8	3.5	4.7
3	33.0	5.5	10.2
4	130.0	11.4	21.6
5	10805.9	-.-	-.-

* RMS on smoothed data

VES-2 in Bitata Bura area

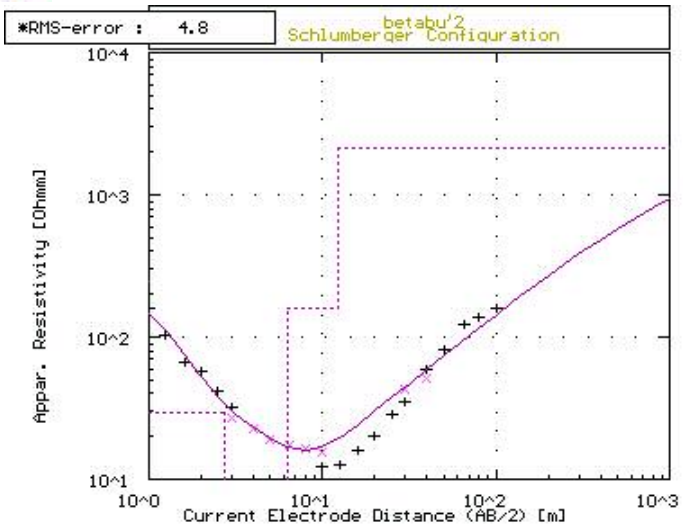


No	Res	Thick	Depth
1	339.9	0.6	0.6
2	80.5	1.9	2.6
3	90.4	4.3	6.8
4	14.0	4.0	10.8
5	103.2	3.8	14.7
6	1425.4	-.-	-.-

* RMS on smoothed data

VES-3 of BitataBura

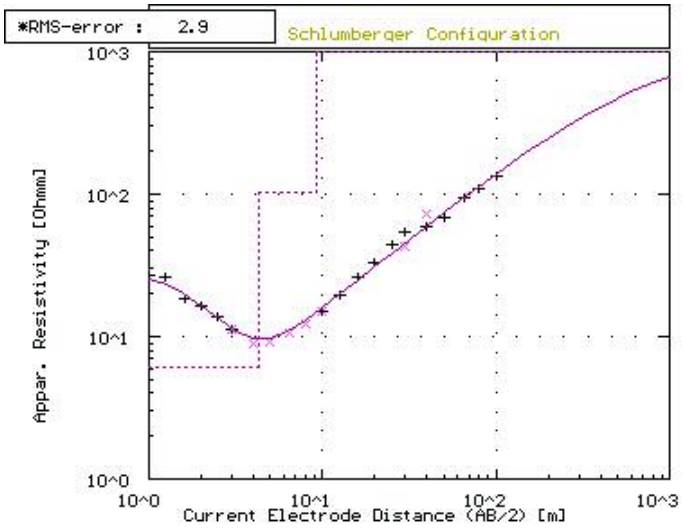
UTM – Universal traverse Marketers
VES- Vertical electrical sounding



No	Res	Thick	Depth
1	248.6	0.5	0.5
2	29.5	2.2	2.7
3	6.6	3.6	6.3
4	158.6	6.0	12.4
5	2137.3	-.-	-.-

* RMS on smoothed data

VES-4 of BitataBura

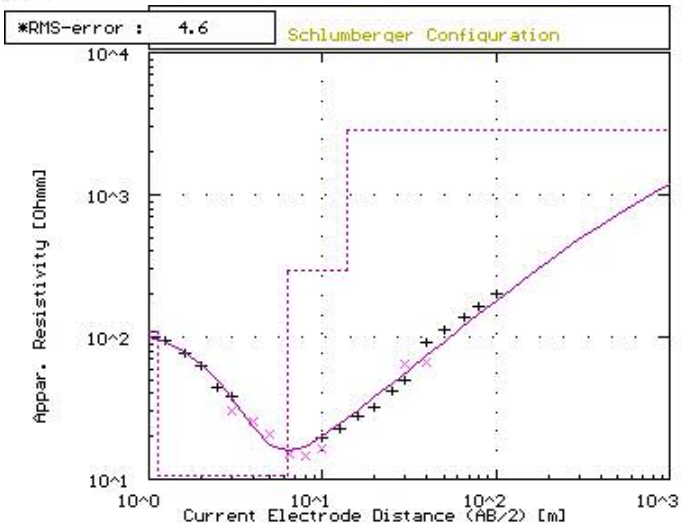


No	Res	Thick	Depth
1	29.2	0.9	0.9
2	6.1	3.4	4.3
3	101.5	4.9	9.1
4	993.3	-.-	-.-

* RMS on smoothed data

VES-5 of BitataBura

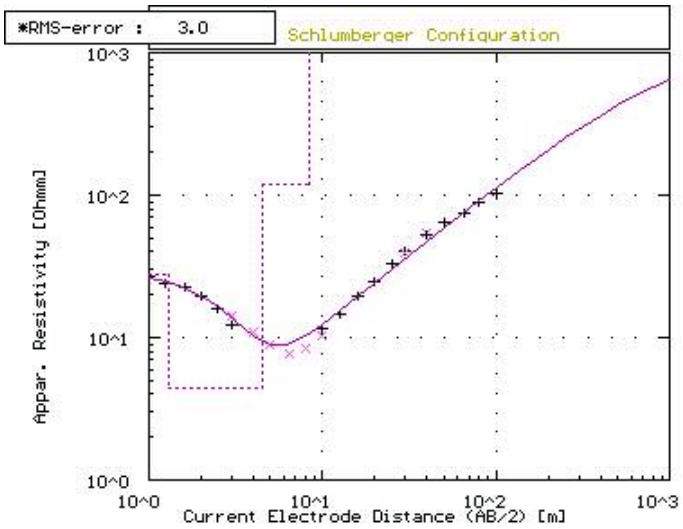
UTM – Universal traverse Marketers
VES- Vertical electrical sounding



No	Res	Thick	Depth
1	110.6	1.1	1.1
2	10.6	5.2	6.3
3	296.0	7.6	13.9
4	2818.7	-.-	-.-

* RMS on smoothed data

VES-6 of BitataBura

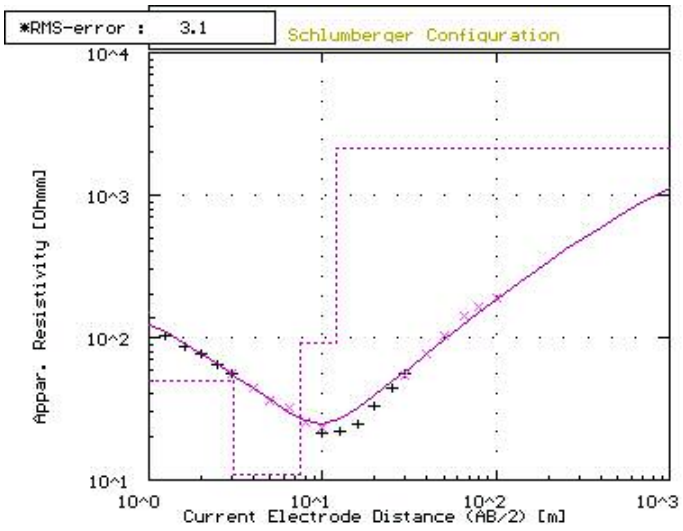


No	Res	Thick	Depth
1	27.7	1.3	1.3
2	4.4	3.2	4.5
3	118.3	3.8	8.3
4	1178.3	-.-	-.-

* RMS on smoothed data

VES-7 of BitataBura

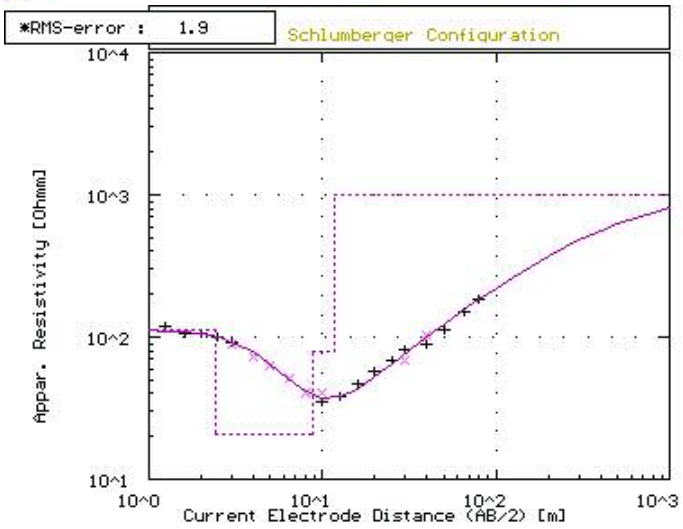
UTM – Universal traverse Marketers
VES- Vertical electrical sounding



No	Res	Thick	Depth
1	151.1	0.7	0.7
2	49.9	2.4	3.1
3	10.9	4.3	7.4
4	91.0	4.7	12.1
5	2153.3	-.-	-.-

* RMS on smoothed data

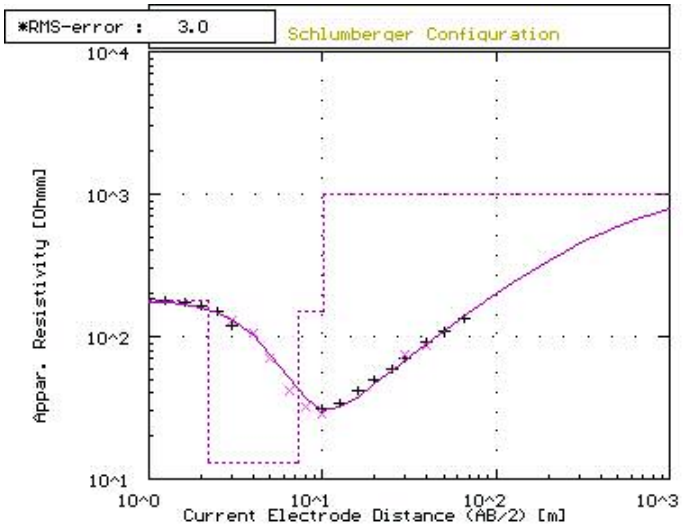
VES-8 of BitataBura



No	Res	Thick	Depth
1	112.4	2.4	2.4
2	20.7	6.3	8.8
3	80.2	3.0	11.7
4	992.9	-.-	-.-

* RMS on smoothed data

VES-9 of BitataBura



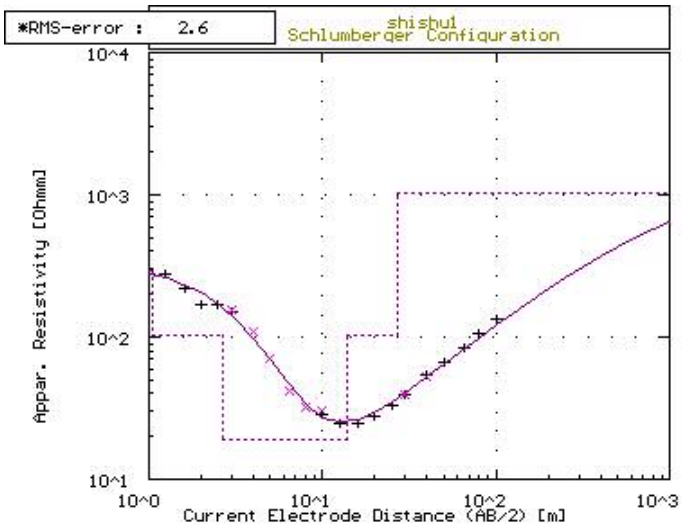
No	Res	Thick	Depth
1	177.1	2.2	2.2
2	13.1	5.0	7.2
3	151.2	3.0	10.2
4	1002.3	-.-	-.-

* RMS on smoothed data

VES-10 of BitataBura

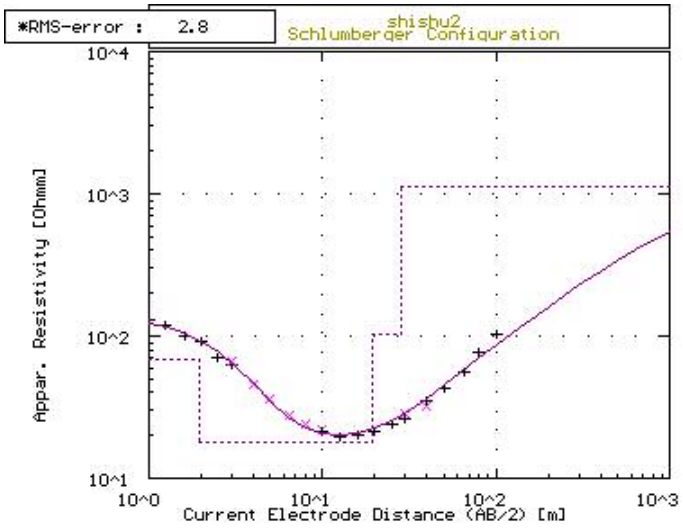
UTM – Universal traverse Marketers
VES- Vertical electrical sounding

Shishu-Geo electrical curve obtained from the survey in Shishu area



No	Res	Thick	Depth
1	296.9	1.1	1.1
2	104.0	1.6	2.7
3	18.9	11.2	13.9
4	104.3	13.3	27.2
5	1033.7	-.-	-.-

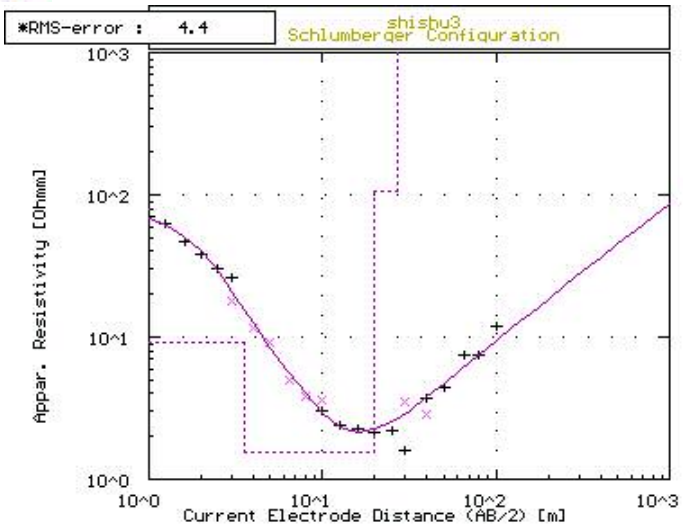
* RMS on smoothed data



No	Res	Thick	Depth
1	131.8	0.9	0.9
2	68.2	1.0	1.9
3	17.8	17.2	19.1
4	102.9	8.9	28.1
5	1113.6	-.-	-.-

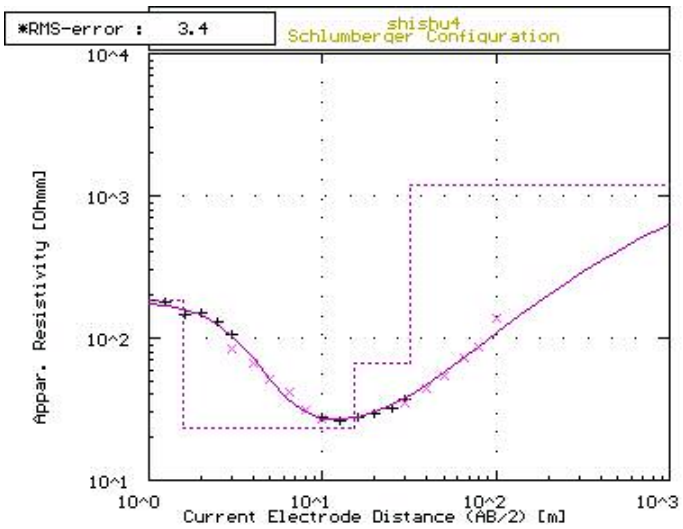
* RMS on smoothed data

UTM – Universal traverse Marketers
VES- Vertical electrical sounding



No	Res	Thick	Depth
1	78.5	1.0	1.0
2	9.3	2.6	3.6
3	1.6	16.0	19.6
4	107.0	7.1	26.7
5	1060.1	-.-	-.-

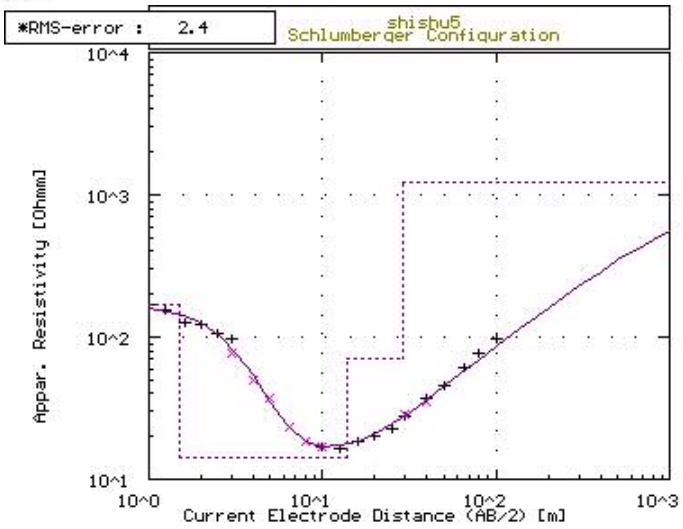
* RMS on smoothed data



No	Res	Thick	Depth
1	182.5	1.6	1.6
2	23.3	13.8	15.4
3	65.6	16.4	31.8
4	1181.2	-.-	-.-

* RMS on smoothed data

UTM – Universal traverse Marketers
VES- Vertical electrical sounding



No	Res	Thick	Depth
1	167.0	1.5	1.5
2	14.4	12.4	13.9
3	69.8	14.8	28.7
4	1224.6	-.-	-.-

* RMS on smoothed data

Interpretation

Haro-HA type curves are obtained from the respective tree soundings. The first layer the soundings has similar thickness in all soundings and it is top soil. The second layer which reveled by low resistivity value possibly indicates the wet clay and the thickness of the clay little bit variable. The third layer which represented by 12.2 in the VES-1, 16.8 in VES-3 and 30.1 in VES-2 indicate the upper weathered and fractured part of Granite that is possibly water bearing. The bed rock in all the sounding is represented by very high resistivity value. The summery of the interpretation is presented in the following table.

VES-1				
No	**Resistivity (ohm-m)**	**Depth(m)**		**Possible litho logy**
		From	**To**	
1	60.5	0	0.4	Clay, silt with minor sand
2	6.4	0.4	3.4	
3	12.2	3.4	8	Fractured granite, possibly water bearing
4	1326.1	8	-	Massive Granite
VES-2				
1	21.3	0	0.5	Clay, silt with minor sand
2	10.1	0.5	2.2	
3	30.1	2.2	9.8	Fractured granite, possibly water bearing
4	1428.2	9.8	-	Massive granite
VES-2				
1	34	0	0	Clay, silt with minor sand
2	5	0.5	0.5	
3	16.8	2.7	2.7	Fractured granite, possibly water bearing
4	1938.3	8.6	8.6	Massive granite

Table-8

Arda Bururi-QHA type curves are obtained from the respective two soundings. The first layer the soundings has similar thickness in both soundings and it is top sandy soil. The second and the third layer which reveled by low resistivity value possibly indicate the wet sandy clay. The fourth layer which represented by 147.5 in the VES-1and 142.7 in VES-2 indicates the upper fractured part of Granite. The bed rock in both sounding is represented by very high resistivity value. The summery of the interpretation is presented in the following table.

VES-1				
No	**Resistivity (ohm-m)**	**Depth(m)**		**Possible litho logy**
		From	**To**	
1	31.3	0	0.6	Top soil
2	14.1	0.6	3.5	Sandy clay, possibly wet
3	6.9	3.5	9.7	
4	147.5	9.7	17.1	Fractured granite
5	2670.3	17.1	-	Massive Granite
VES-2				
1	34	0	0.7	Top soil
2	14.8	0.7	3.3	Sandy clay, possibly wet
3	7.8	3.3	9.7	

UTM – Universal traverse Marketers
VES- Vertical electrical sounding

4	142.7	9.7	17.9	Fractured granite
5	2259.2	17.9	-	Massive granite

Table-9

***Bitata Bura*-**In the area around BitataBura the granite unit exposed along local stream lines and on hillsides. Along the stream lines the granite unite covered by highly weathered and altered clay material and it appear as three-horizon stratification at VES -1 center. The thickness of the first layer is 0.9m with resistivity value of 41.1Ω-m while the second has a thickness of 3.8m with resistivity value of 4.7Ω-m. These two successive layers are possibly clay with variable proportion of sand. Especially the second layer could be wet clay material. The third layer has the resistivity value of 45.5Ω-m and it extends up to 6.4m. Probably sand-silt deposit could be favorable for ground water storage and movement. The bedrock detected below 6.4m by high resistivity value.

Unlike to the result obtained from VES-1, the second VES resulted in five geo-electrical layering. With exception of minor thickness variation, the top three layers of VES 2 are very consistent with the first three layers of VES-1. The fourth layer of VES -2 has moderately high resistivity value (130 Ω-m) and it possibly represent the fractured part of the granite. This layer extends up to 21.6m and it underlain by fresh massive granite (10805.9Ω-m). The summery of the first two sounding is presented in the following table.

VES-1				
No	**Resistivity (ohm-m)**	**Depth(m)**		**Possible litho logy**
		From	**To**	
1	41.4.	0	0.9	Clay, silt with sand
2	4.7	0.9	3.7	
3	45.5	3.7	6.4	Fractured granite or sand, possibly water bearing
4	1839.1	6.4	-	Massive Granite
VES-2				
1	41.4	0	1.2	Sandy silt
2	24.1	1.2	4.7	Sand possibly water bearing
3	57.9	4.7	10.2	Fractured granite, could be wet
4	130	10.2	21.6	Hardly fractured granite
5	10805.9	21.6	-	Massive granite

Table-10

7m deep hole excavated at the center of VES-1, but the result obtained is not consistent to what expected from the geoelectrical survey. Although the result obtained from the first sounding is not good, the hydro-geologic condition of the area strongly favors the existence of shallow ground water.

UTM – Universal traverse Marketers
VES- Vertical electrical sounding

To further more understanding of the sub surface layering characteristics and lateral layering variation of the different layers eight VESs had been carried out across the stream channel of the area, by systematically aligning the VES centers in two grids. For the first four soundings the internal separation of VES centers were 30m while for the other four soundings the inter-central distance ranges from 15-30m.

As shown the curves, except the VES three and VES four, all are resulted in to HA- curve. VES-3 and VES-4 resulted in to HKHA type and QHA type, respectively. However, the general layering characteristic looks harmonic and very resemble that of VES-2 conducted in the area previously. Thus, the interpretation techniques preferred to follow the systematic trend of pseudo-geoelectrical layers rather than interpreting the layers based on specific resistivity value. This might help to delineate the buried underground structure, if it is present, and help full to understand the lateral variation of the clay bed, which usually mislead with the water-bearing layer.

UTM – Universal traverse Marketers
VES- Vertical electrical sounding

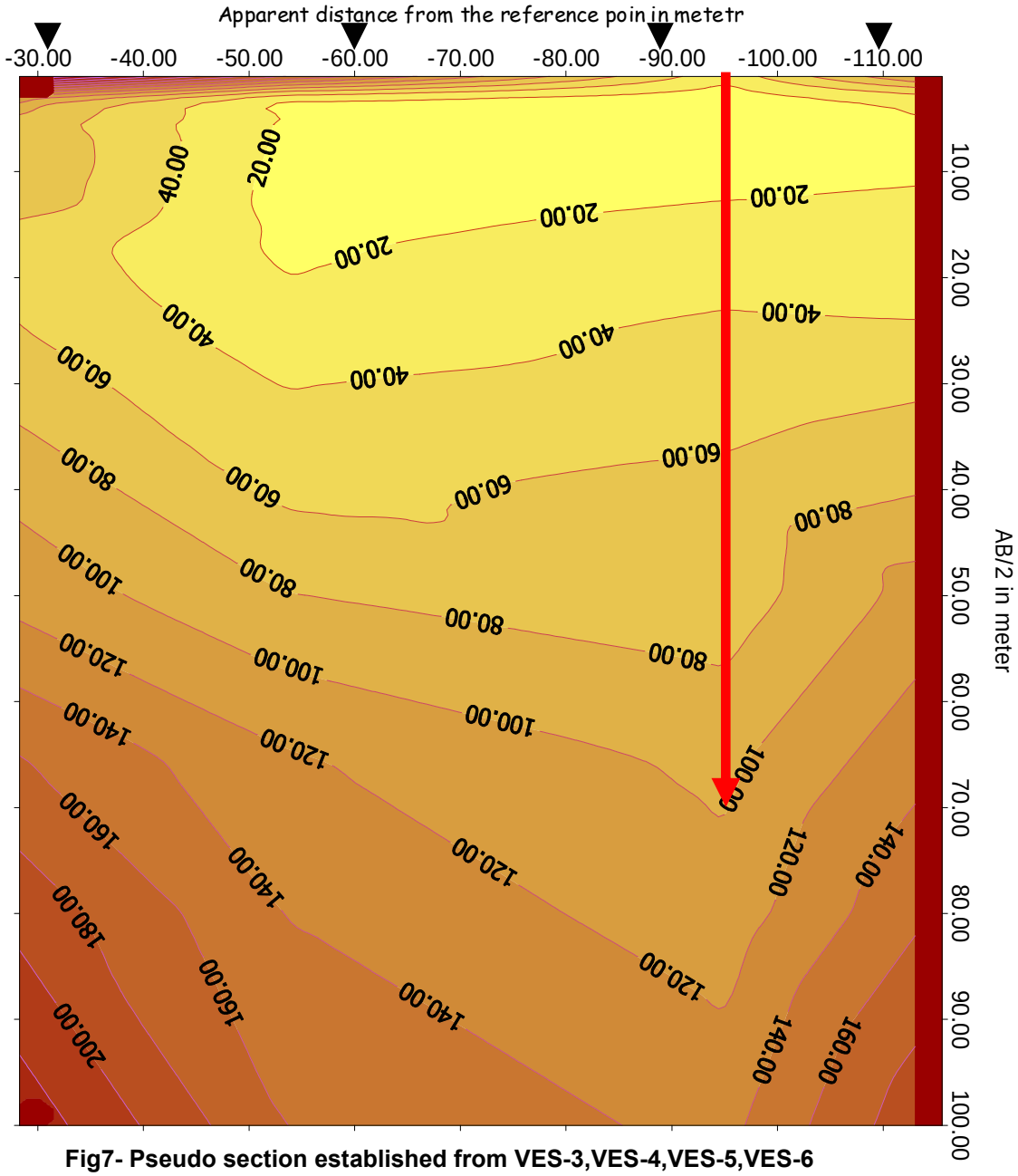


Fig7- Pseudo section established from VES-3,VES-4,VES-5,VES-6

UTM – Universal traverse Marketers
VES- Vertical electrical sounding

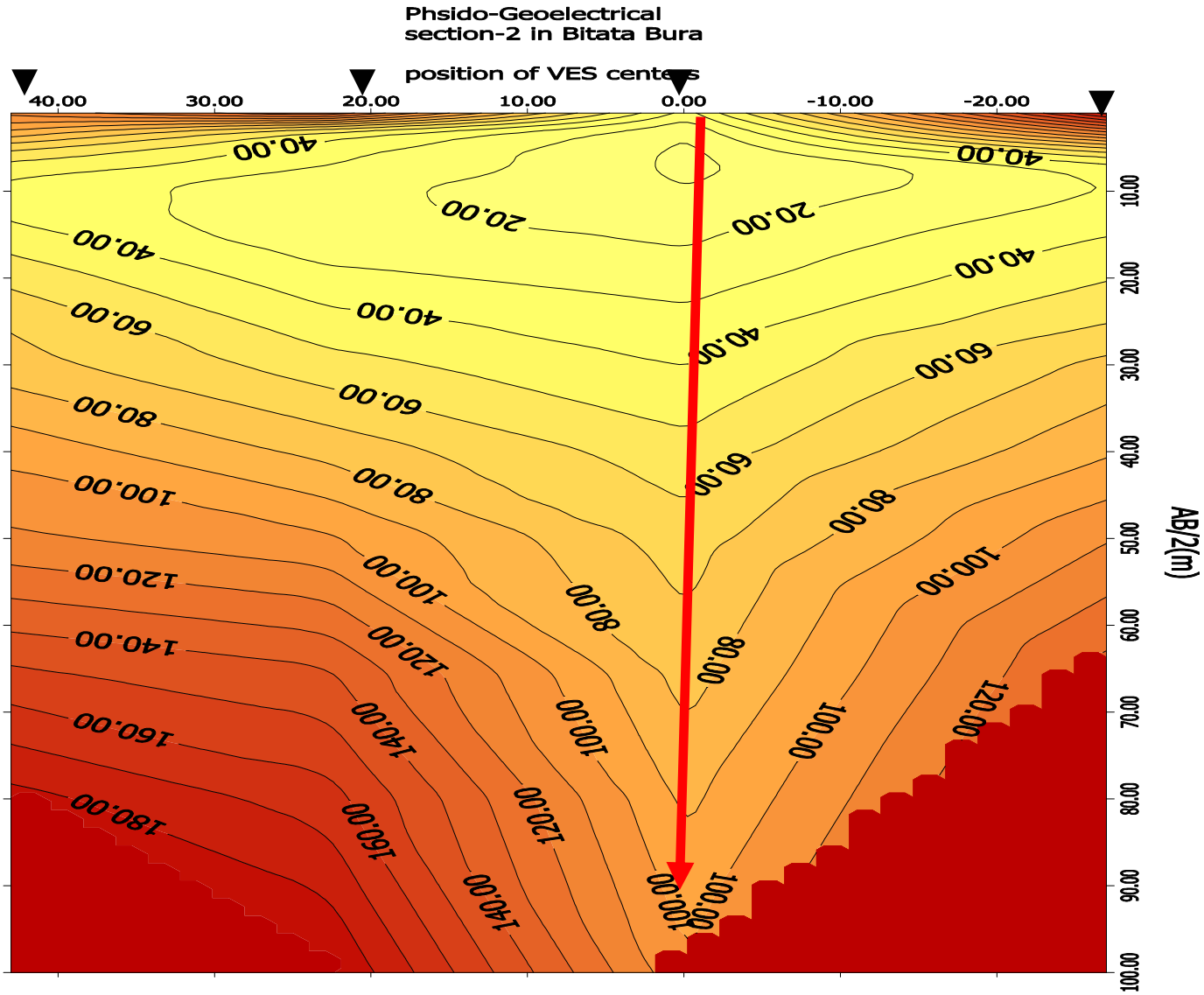


Fig8- Pseudo section established from VES-7,VES-8,VES-9,VES-10

The first-established pseudo geo-electrical section indicate that the thickness of the less resistive layer decrease in both direction from the center of VES-5. Similar kind of trending is observable by centering VES-7. Beside the center of VES-5 and the center of VES 7 are nearly on a line going along the stream. From the sections, one can understand that the buried water-bearing channel is much localized, possibly indicating fracture or join. Thus, thus the expected water bearing media possibly related with rock fracture. The red line shown on the pseudo-section established from the VESs possibly indicates the existing buried structure in the area. Accordingly it is recommended to locate the second well at the center of VES-5.

UTM – Universal traverse Marketers
VES- Vertical electrical sounding

Shishu- as shown on the curves all the soundings, except the fourth & fifth, resulted in QH type curve. The fourth and the fifth sounding shows HA type curve. In all the soundings the first layer represented by higher resistivity value possibly indicate very porous top layer and the second layer indicated by lower resistivity value in VESs from three up to five, but in VES-1 and in VES-2 it has higher resistivity value. The third layer has variable thickness in all the soundings and it followed very high resistant rock. The summery of the geoelectrical interpretation in to lithological layering is shown in the following table.

VES-1				
No	**Resistivity (ohm-m)**	**Depth(m)**		**Possible litho logy**
		From	**To**	
1	296.9	0	1.1	silt with sand
2	104	1.1	2.7	
3	18.9	2.7	13.9	Sand, possibly water bearing
4	104.5	13.9	27.2	Hardly fractured granite
	1033.7	27.2	-	Massive Granite
VES-2				
1	131.8	0	0.9	silt with sand
2	69.2	0.9	1.9	
3	17.9	1.9	19.1	Sand, possibly water bearing
4	102.9	19.1	28.1	Hardly fractured granite
5	1113.6	28.1	-	Massive granite
VES-3				
1	78.5	0	1	silt with sand
2	9.3	1	3.6	
3	1.6	3.6	19.6	
4	107	19.6	26.7	Hardly fractured granite
5	1060	26.7	-	Massive Granite
VES-4				
1	187.5	0	1.6	silt with sand
2	23.3	1.6	15.4	Sand, possibly water bearing
3	65.6	15.4	31.8	Fractured granite, possibly water bearing.
4	1181.2	31.8	-	Hardly fractured granite
VES-5				
1	167	0	1.5	silt with sand
2	14.4	1.5	13.9	Sand, possibly water bearing
3	69.8	13.9	28.7	Fractured granite, possibly water bearing
4	1224.6	28.7	-	Massive Granite

Table-11

UTM – Universal traverse Marketers
VES- Vertical electrical sounding

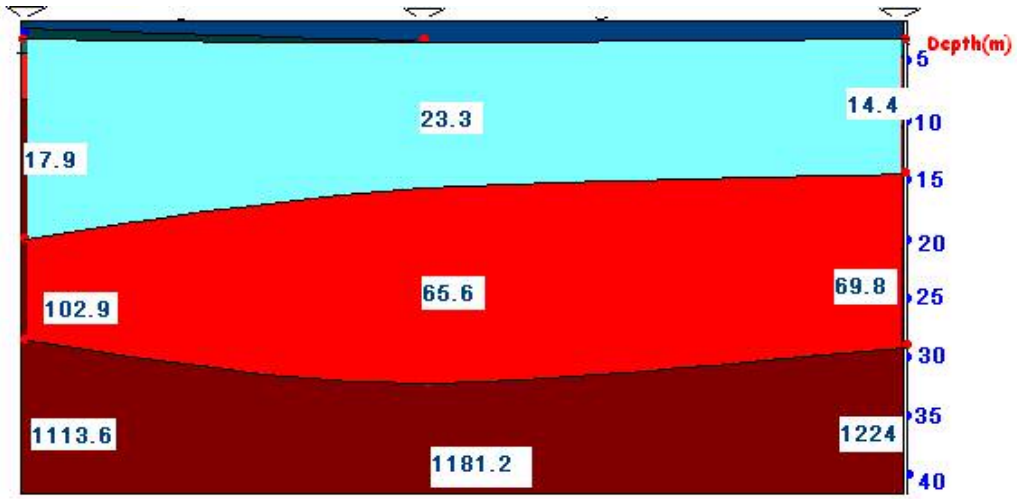


Fig9- Geo-electrical section established from VES2, VES4, VES5 in Shishu

The geoelectrical section shows the thickness of the conductive (shown with the light blue) decrease towards the last VES5. Thus the well site recommended locating near by of VES-1 and two.

UTM – Universal traverse Marketers
VES- Vertical electrical sounding

5- The Area By West of the Main Road

5-1 Location

In section it is included the areas by west of the main Addiss Abeba – Negele road. It extends from west of HareKelo to west of Negele. In the northern part it comprises the area between HareKelo and Awata River and in southern it extends from Negele to west up to Jidola village.

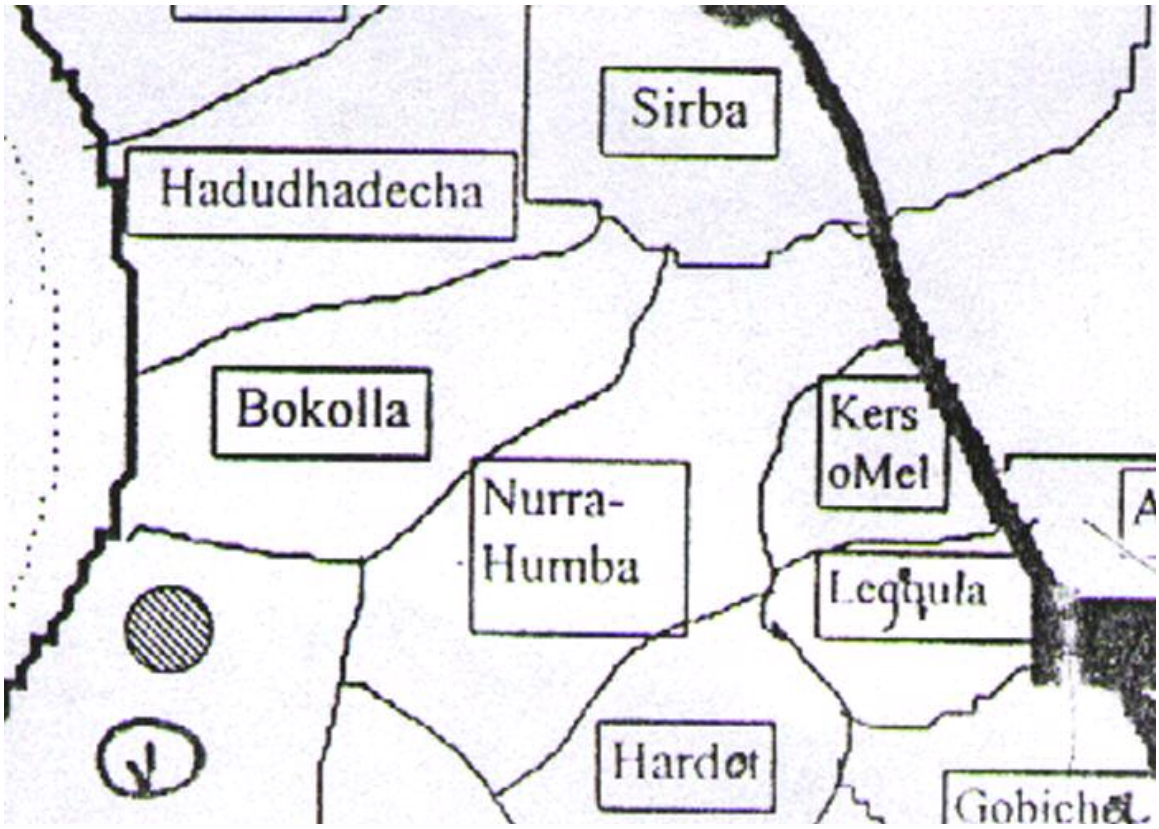


Fig-10 Location Map, the sketch is not on to scale

5-2 Geology of the area

The area appears as rugged terrain with mountain ridges and small granitic domes. There are a number of small seasonal stream lines with the general flow direction to south. River Awata is the lonely perennial river existing in the area, and it forms the western boundary of the area in the north part. The drainage pattern of the existing seasonal streams as well as Awata River is structural controlled to semi dendritic drainage pattern.

Precambrian crystalline basement rocks are the most prominent rock units in the area. Among the Precambrian crystalline rocks, rocks that are belonging to Algae group are the major rocks in forming the local geological set up of the area. This Group consists of biotite-hornblende gneiss with subordinate biotite, hornblende-biotite, quartzo-feldspatic gneiss, biotite, deformed and/or undeformed biotite granite as well as migmatite. In addition to the gneiss rocks, schist of different composition occurs as minor lenses. The unit often cut by discordant and concordant pegmatitic and quartz vein and veinlets. It exists in the area as North to south running belt with the gradual contact with the western Awata Gneiss.

The other rock type exposed in the area is Awata gneiss is constituted mainly of biotite-plagioclase-microcline-quartz mylonite with presence of migmatized hornblende-biotite gneiss and hornblende gneiss. It exposed in the western part of the district in side Wadera shear zone. The contact with adjoining unit is gradational. Locally the gneissic unit formed elongated dome which intruded by syn tectonic as well as pre tectonic granite. It is dominantly composed of plagioclase, quartz and biotite and formed light grey to light brown colored thin elluvium at the top.

Post tectonic Granite is one the most prominent rocks in the area. It covered wide area between Bitata village and HareKelo. It formed elevated land and hills. It is pinkish grey, medium to course grained, in equiangular and massive. It commonly shows micrographic inter growth of quartz and plagioclase crystals. The contact of this granite pluton with intruded country rock in generally not sharp.
Undifferentiated alluvium and eluvium deposits also exist in the area along the major seasonal stream lines. It is composed of sand, silt and clay with different proportion of gravel. It is much localized along stream lines and gentle planes.

Tectonic features are observable in the area and most of the tectonic features created as result of shear movement related with WSZ. This can be justified by the existence of many hardly dislocated open fractures with major strike of Northwest to

UTM – Universal traverse Marketers
VES- Vertical electrical sounding

southeast. From the aerial photographs one can easily recognize the existence of north to south striking tectonic lineament, too.

Most of the crystalline basement rocks of the area are very compacted and have no any primary porosity. The existence as well as the movement of ground water in such rocks mainly related with secondary porosity developed on the rock as result of surfacial processes and tectonism. Locally, the fracture system developed on the major hard rocks i.e. granite and gneiss as well as shiest is expected to be the favorable media for shallow ground water movement as well as recharging the shallow ground water from the rain

The aquifer system of the area is expected to be shallow ground aquifer formed as result of saturation fractured basement rocks as well as fractured intrusives, which located at the contact of the granite and gneissic unit and inside the Wadera Shear Zone. In addition to the fractured hard rocks, alluvial deposits that found along the major stream lines also could be the favorable place for ground water existence.

On the above bases the sites are selected for either for further detail study or for directly implementation of the water intervention. The name lists of the sites are: Sirba, Bokola, Jidola, Minga, Nura Amba, Mede, Garmedo Sirba, and Tula Dhelan.

5-3 Geophysical survey

The detail survey not carried out in Bokola, Mede, Nura Amba, Tula Dhelan because the existing hydro geological condition of the areas strongly favors the existence of the ground water in the area. Geophysical survey was carried in Sirba, Jidola and Minga and Garmedo sirba.

Data Acquisition

Sirba-Two VESs were conducted in Sirba. The first sounding was centered at 612309m north and 539822m east. The spreading was parallel to the streamline with azimuth of $N240^0$. Like wise, the second was done by spreading the electrode along the same streamline, few hundreds of meters dawn streamside. The azimuth of the second sounding is $N85^0$ and the geographic coordinate of the center is 539521m east and 612076m north.

Jidola-Three vertical electrical sounding was conducted on the streamline near the village of Jidola. The first sounding was conducted, few tens of meters away and down streamside from the road, across the streamline. While the second has been done across the confluence of two small valleys on the up streamside to the road and third conducted along the main stream, further up streamside. The centers and alignment of the soundings are summarized in the following table.

UTM – Universal traverse Marketers
VES- Vertical electrical sounding

Position	VES-1	VES-2	VES-3
NORTH	594941	594995	595056
EAST	533476	533407	533356
AZIMUTH	30 N	30 N	140 N

Table-12

Two vertical electrical soundings carried out in Minya. Both two soundings are conducted on Minga stream. The azimuth of the first sounding was north-south while the second one has $N25^0$. The first sounding was centered at 592923m north and the second one was centered at292830m north and 535572m east.

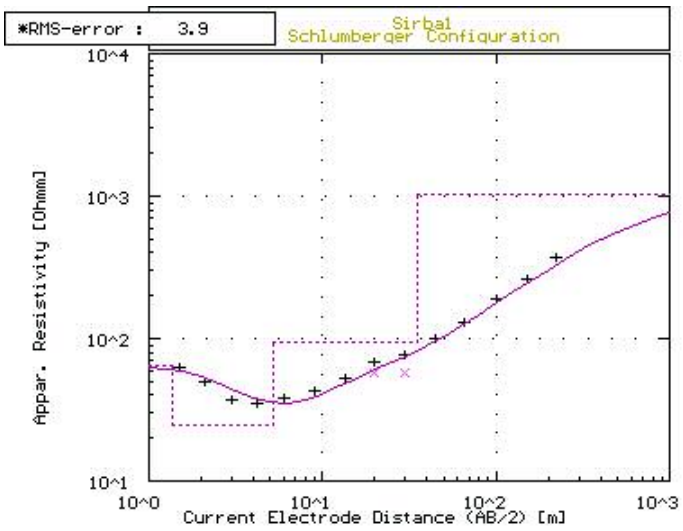
Seven electrical soundings were carried out in GermedoSirba area. The position of centers and the azimuth of the spreading are summarized in the following table.

Position	VES-1	VES-2	VES-3	VES-4	VES-5	VES-6	VES-7
NORTH	610684	610715	610746	610675	610722	610701	610729
EAST	545462	545463	545465	54538	545378	545169	545074
AZIMUTH	10 NE	10 NE	10NE	15 NE	15NE	160 NE	EW

Table-13

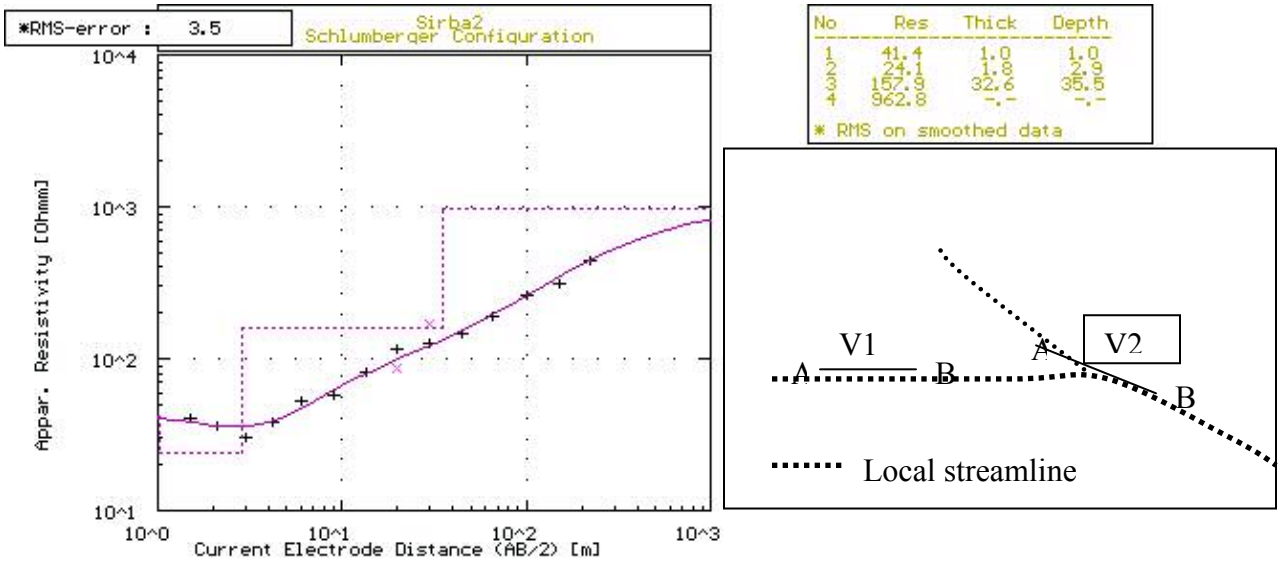
Data Analysis

Sirba- The VESs that carried out In Sirba resulted in four geo-electrical layers, with *HA geo-resistivity type-curves.

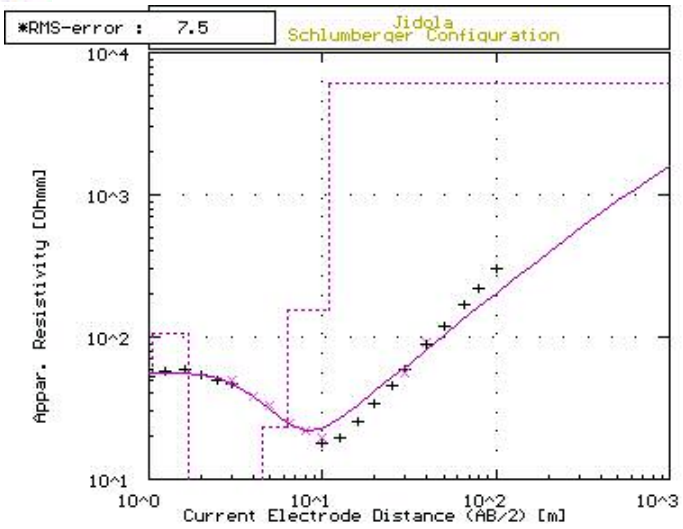


No	Res	Thick	Depth
1	65.4	1.4	1.4
2	24.4	3.8	5.1
3	95.4	29.7	34.8
4	1043.3	-.-	-.-

* RMS on smoothed data

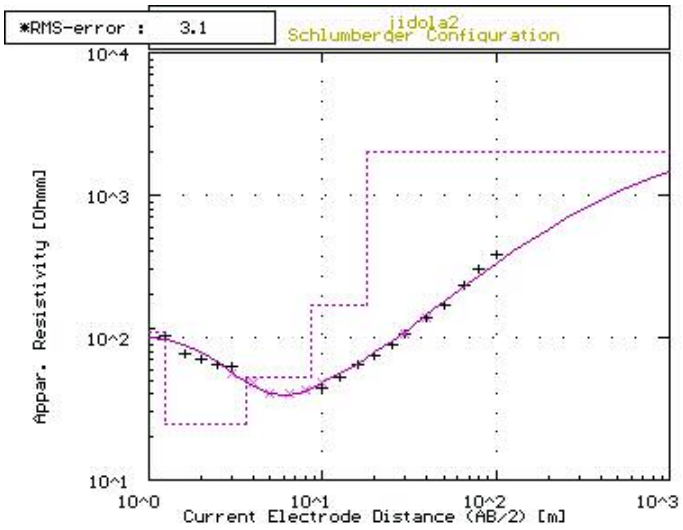


Jidola- The VESs that carried out in Jidola resulted in KHA, HA and HA geo-resistivity type-curves, respectively. The first sounding resulted in 6 layer geoelectrical model while the other two resulted in 5 geoelectrical layering models.



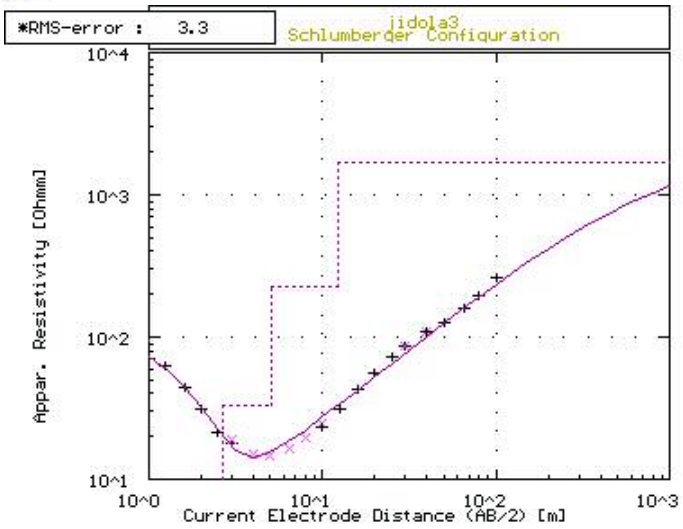
No	Res	Thick	Depth
1	55.3	1.1	1.1
2	106.2	0.7	1.7
3	8.2	2.8	4.5
4	23.0	1.8	6.4
5	166.7	4.5	10.9
6	6056.7	-.-	-.-

* RMS on smoothed data



No	Res	Thick	Depth
1	108.0	1.2	1.2
2	24.8	2.4	3.7
3	52.2	4.9	8.6
4	168.2	9.4	18.0
5	1999.8	-.-	-.-

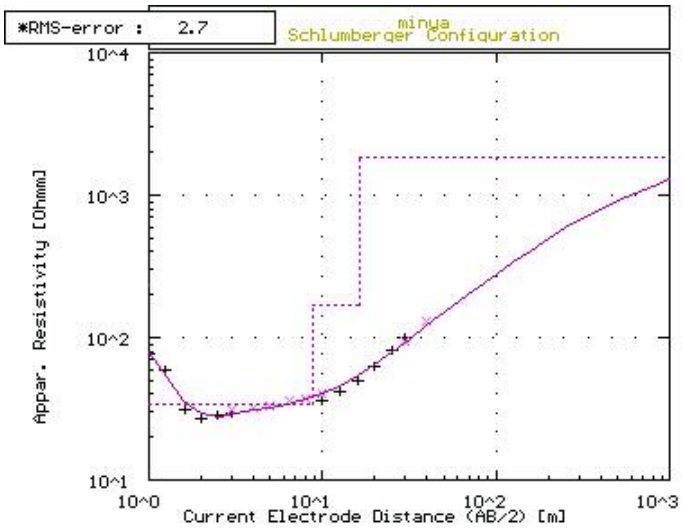
* RMS on smoothed data



No	Res	Thick	Depth
1	94.3	0.8	0.8
2	7.3	1.9	2.7
3	33.0	2.5	5.1
4	225.6	7.3	12.4
5	1696.8	-.-	-.-

* RMS on smoothed data

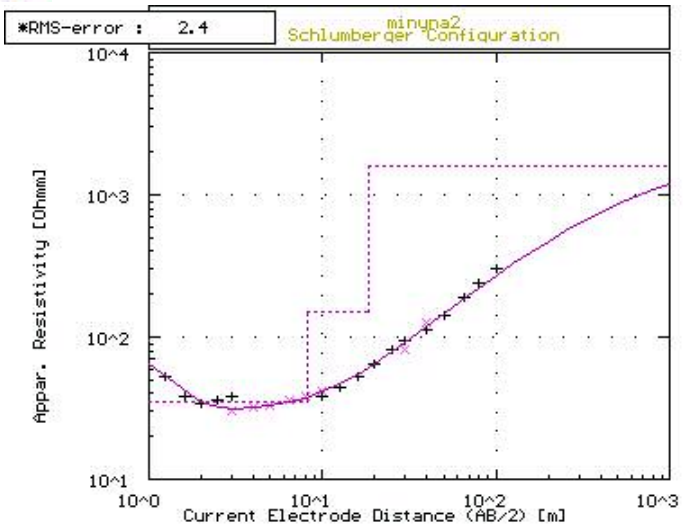
Migna- The two VESs carried out in Migna resulted in similar HA type curve. As shown on the curves the detected geoelectrical layers are similar in terms of resistivity value as well as depth in both curves.



No	Res	Thick	Depth
1	233.7	0.4	0.4
2	11.6	0.4	0.8
3	34.5	7.9	8.7
4	169.7	7.7	16.4
5	1830.4	-.-	-.-

* RMS on smoothed data

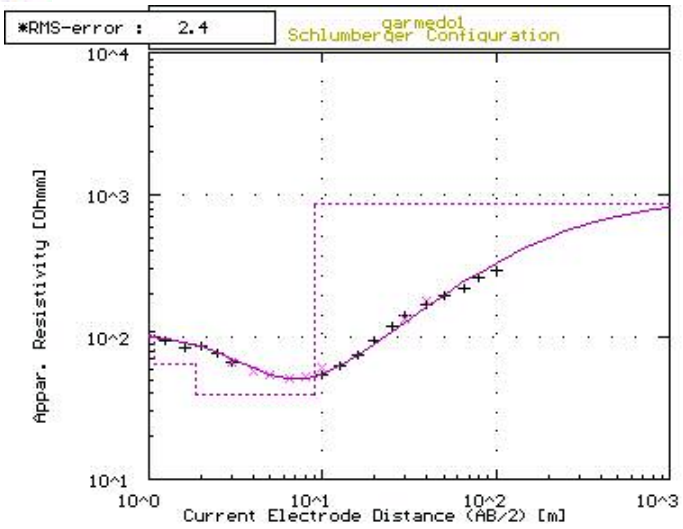
UTM – Universal traverse Marketers
VES- Vertical electrical sounding



No	Res	Thick	Depth
1	94.7	0.6	0.6
2	13.4	0.4	1.0
3	34.6	7.3	8.2
4	151.9	10.4	18.7
5	1601.6	-.-	-.-

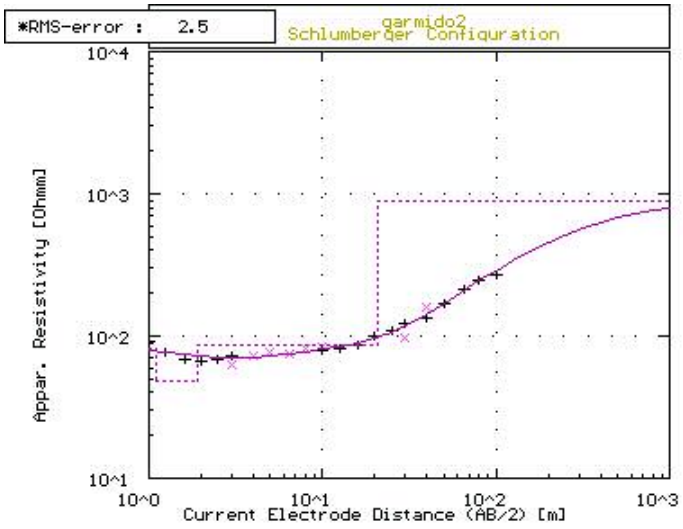
* RMS on smoothed data

Garmedo Sirba- HQ, HA, HA, HA, HKHA, HKAH and HKHA type curves are obtained from the respective seven soundings carried out in Garmedo Sirba. VES-1, VES-2, VES-4 are resulted in four layered geoelectrical models, while VES-3 resulted in 5 layer geoelectrical model. The rest of the VESs are resulted in six layered geoelectrical models.



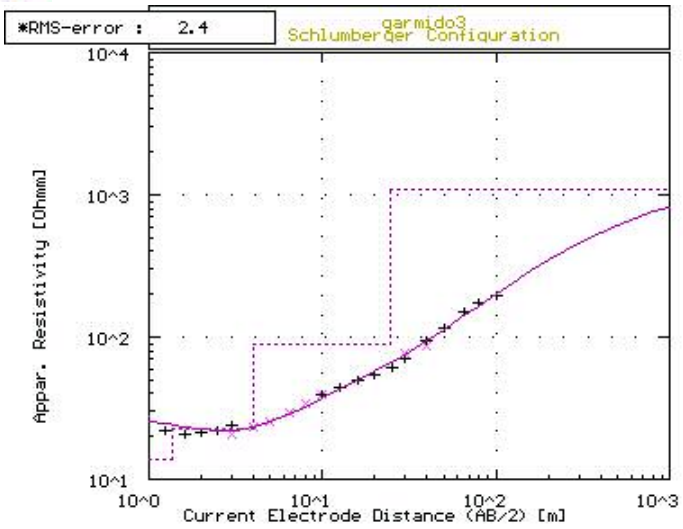
No	Res	Thick	Depth
1	103.6	1.1	1.1
2	64.2	0.8	1.9
3	39.1	7.1	9.0
4	874.0	-.-	-.-

* RMS on smoothed data



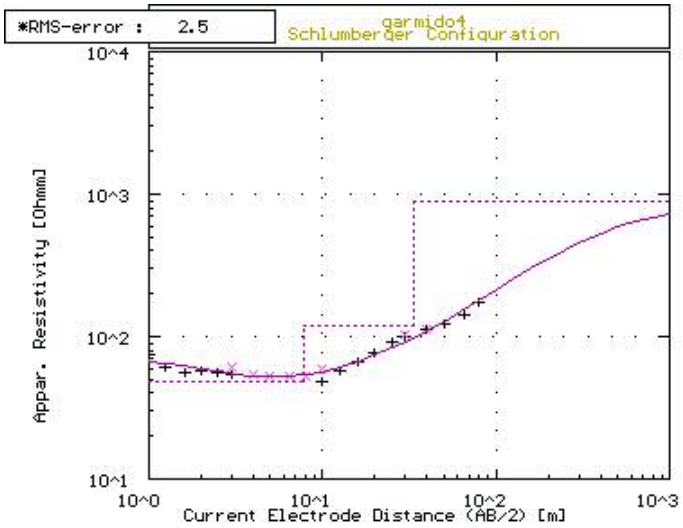
No	Res	Thick	Depth
1	80.9	1.1	1.1
2	47.7	0.8	1.9
3	85.6	18.8	20.7
4	890.5	-.-	-.-

* RMS on smoothed data



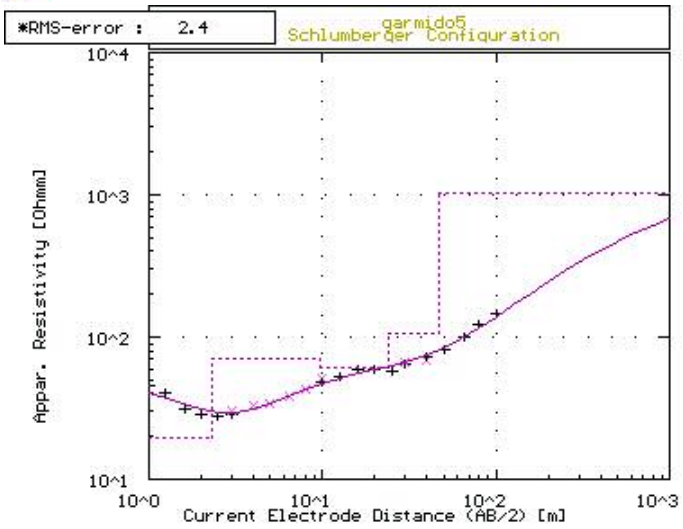
No	Res	Thick	Depth
1	27.8	0.8	0.8
2	13.8	0.6	1.4
3	22.4	2.7	4.0
4	89.2	20.5	24.6
5	1082.1	-.-	-.-

* RMS on smoothed data



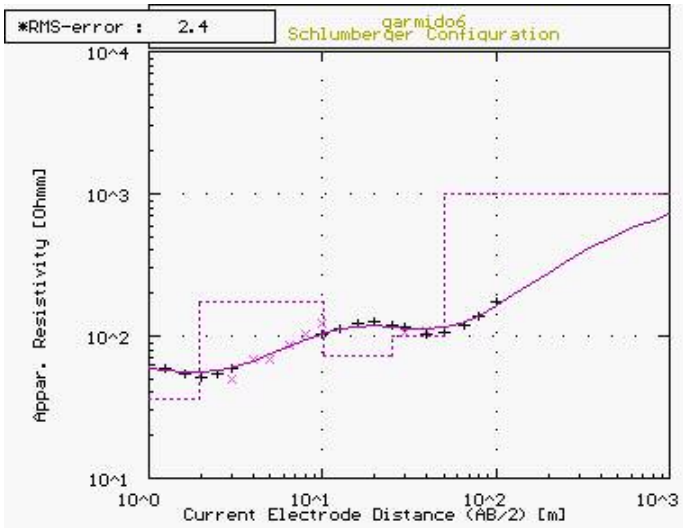
No	Res	Thick	Depth
1	67.7	1.0	1.0
2	47.9	6.9	7.9
3	118.9	25.8	33.7
4	881.6	-.-	-.-

* RMS on smoothed data



No	Res	Thick	Depth
1	45.4	0.8	0.8
2	18.4	1.6	2.3
3	71.3	7.3	9.6
4	61.2	14.1	23.7
5	107.0	23.4	47.1
6	1024.0	-.-	-.-

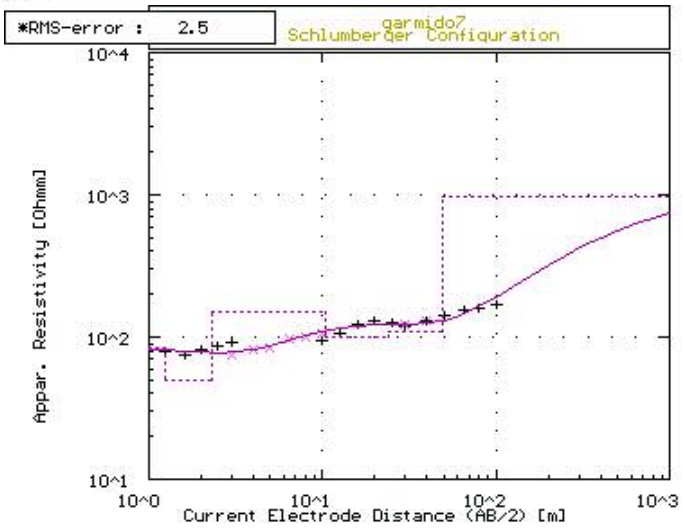
* RMS on smoothed data



No	Res	Thick	Depth
1	61.4	0.9	0.9
2	36.3	1.1	2.0
3	174.4	8.2	10.2
4	73.5	14.8	25.0
5	99.6	25.1	50.1
6	1003.1	-.-	-.-

* RMS on smoothed data

UTM – Universal traverse Marketers
VES- Vertical electrical sounding



No	Res	Thick	Depth
1	84.0	1.2	1.2
2	49.3	1.1	2.3
3	149.6	8.1	10.4
4	101.1	13.7	24.2
5	110.6	25.0	49.1
6	974.7	-.-	-.-

* RMS on smoothed data

Interpretation

Sirba- The VESs that carried out In Sirba resulted in four geo-electrical layers, with HA geo-resistivity type-curves. Both curves have nearly the same geo-electrical layering model with minor variation in respect to thickness. The variation of thickness possible happened because of lateral compositional variation of top sediment material. Accordingly, the interpretation of geo-electrical layering of Sirba area in to litho logical layering is likely be as follows. The first layers of two soundings with resistivity value of 65.4Ω-m and 41.4Ω-m are clay soil. The second layer in both soundings represented by nearly equal resistivity value that is 24Ω-m and it is a layer of alluvial deposit of sand with silt. This layer possibly represents the shallow ground water bearing layer of the area. The fourth and the fifth layers in both soundings reveal the stratification of hard layer forming the bedrock. The bedrock could be either granite that is highly weathered and fractured at the top part or could be weathered schist at the top part. The interpretation summarized in the following table.

VES-1				
No	**Resistivity (ohm-m)**	**Depth(m)**		**Possible litho logy**
		From	**To**	
1	65.4	0	1.4	Clay hard
2	24.4	1.4	5.1	Sand with some clay
3	95.4	5.1	34.8	Weathered and Fractured Granite
4	1045	34.8	-	Fresh Granite

VES-2				
1	41.4	0	1	Clay hard
2	24.1	1	2.9	Sand with clay, possibly water bearing
3	157.9	2.9	35.5	Weathered and Fractured Granite
4	962.9	35.5	-	Fresh Granite

Table-14

Jidola- The VESs that carried out in Jidola resulted in KHA, HA and HA geo-resistivity type-curves, respectively. The first sounding resulted in 6 layer geoelectrical model while the other two resulted in 5 geoelectrical layering models. The result of the first layer differs from the result of the other two soundings. This might happened because of the existence of loom-soil in the top at the center of VES-1. The second layer of VES-1 is correlation able with the first layers of the other VESs. It possibly indicate sandy soil which followed by clay layer. The fourth layer of VES-1 and the third layer of the other two VES is possibly water bearing sand and it followed by hardly fractured basement rock. In all VESs the bed rock is represented by high resistivity value. The summery of the interpretation presented in the following table.

VES-1				
No	**Resistivity (ohm-m)**	**Depth(m)**		**Possible litho logy**
		From	**To**	
1	55.3	0	1.1	Loose soil
2	106.2	1.1	1.7	Clay hard with sand
3	8.2	1.7	4.5	Clay
4	23	4.5	6.4	Sand
5	156.7	6.4	10.9	Fractured Granite
6	6056.7	10.9	-	Massive Granite
VES-2				
1	108	0	1.2	Clay hard with sand
2	24.8	1.2	3.7	Sand with clay, possibly water bearing
3	52.2	3.7	8.6	
4	168.2	8.6	18.0	Fractured Granite
5	1999.8	18.0	-	Fresh Granite
VES-3				
1	94.3	0	0.8	Clay hard with sand
2	7.3	0.8	2.7	Sand with clay, possibly water bearing
3	33	2.7	5.1	
4	225.6	5.1	12.4	Fractured Granite
5	1696.8	12.4	-	Fresh Granite

Table-15

UTM – Universal traverse Marketers
VES- Vertical electrical sounding

Migna- The two VESs carried out in Migna resulted in similar HA type curve. As shown on the curves the detected geoelectrical layers are similar in terms of resistivity value as well as depth in both curves. The summery of the result is tabulated below.

VES-1				
No	**Resistivity (ohm-m)**	**Depth(m)**		**Possible litho logy**
		From	**To**	
1	233	0	0.4	Clay hard
2	11.6	0.4	0.8	Clay
3	34.5	0.8	8.7	Sand, possibly water bearing
4	169.7	8.7	16.4	Fractured gneiss
5	1830.4	16.4	-	Fresh gneiss
VES-2				
1	94.7	0	0.6	Clay hard
2	13.4	0.6	1	Clay
3	34.6	1	8.2	Sand, possibly water bearing
4	151.9	8.2	18.7	Fractured gneiss
5	1601.9	18.7	-	Fresh gneiss

Table-16

Garmedo Sirba- Regardless of the near ness of sites different kind of geoelectrical curves are obtained. The interpretation of the in to lithological layering is summarized in the following tables for the respective seven surveys.

VES-1				
No	**Resistivity (ohm-m)**	**Depth(m)**		**Possible litho logy**
		From	**To**	
1	103.6	0	1.1	Loose soil
2	64.2	1.1	1.9	Clay hard with sand
3	39.1	1.9	9	Sand
4	874	9	-	Hardly fractured Granite
VES-2				
1	80.9	0	1.1	Loose soil
2	47.7	1.1	1.9	Clay hard with sand
3	85.6	1.9	20.7	Sand
4	890.5	20.7	-	Hardly fractured Granite
VES-3				
1	27.8	0	0.8	Clay with sand
2	13.8	0.8	1.4	Clay

UTM – Universal traverse Marketers
VES- Vertical electrical sounding

3	22.4	1.4	4	Sand, possibly water bearing
4	89.2	4	24.6	
5	1082.1	24.6	-	Granite
VES-4				
1	67.7	0	1	Loose soil
2	47.9	1	7.9	Sand
3	118.9	7.9	33.7	Fractured granite
4	881.6	33.7	-	Hardly fractured Granite
VES-5				
1	45.4	0	0.8	Clay with sand
2	19.4	0.8	2.3	
3	71.3	2.3	9.6	Sand
4	61.2	9.6	23.7	
5	107.0	23.7	47.1	Fractured Granite
6	1024	47.1	-	Granite
VES-6				
1	61.4	0	0.9	Clay with sand
2	36.3	0.9	2	Sand, possibly water bearing
3	174.4	2	10.2	Weathered and fractured granite
4	73.5	10.2	25	
5	99.6	25	50.1	
6	1003.1	50.1	-	Granite
VES-7				
1	84	0	1.2	Clay with sand
2	49.3	1.2	2.3	Sand, possibly water bearing
3	149.6	2.3	10.4	Fractured granite
4	101.1	10.4	24.2	
5	110.6	24.2	49.1	
6	974.7	49.1	-	Granite

Table-17

6- Final Remark and Recommendations

6-1 Final Remarks

The existing socio economic condition of should be strongly considered before any activity related with development intervention in rural and sub urban areas. Properly justifying the livelihood condition of the communities living in the respective project area is the indispensable part for the sustainability of any formulated development projects. This is especially very important for water intervention projects for rural communities, and before the actual physical implementation of project the interest of the community towards the project shall be evaluated.

COOPI is currently under going implementation of water intervention projects for the rural and urban communities living in Liben woreda under frame work of "DROUGHT CONSEQUENCES ALLEVIATION PROJECT IN BORENA ZONE". The implementation of the project was started by identifying the places where the shortage of water is high, and after conducting the social survey in selected areas, Hydro geological and geophysical assessment had carried out in places where suggested from the social survey.

The complexity of the geology of the woreda with other hydrological factors makes the existence of exploitable shallow depth ground water very localized in certain areas. The existence of shallow depth ground water in the district is mainly related with the deposited alluvial sediments along the bank of seasonal stream valleys, and partly on the weathering and fracturing developed on the hard rocks.

The hydro geological carried out in the area are come up with the identification of places where there is high probability of getting ground water and the places where the existing ground water can be developed properly. All the selected places are in rural areas with exceptional of Wefe and Haro.

The geophysical survey were carried out to understand the under ground layering characteristics and the thickness of the less resistive media. The survey was done in selected places where it is necessary and where the local topography permits such kind of survey.

6-2 Recommendations

The hydro geological and geophysical surveys carried out in the respective areas indicate the higher probability of getting shallow ground water in the fore mentioned areas. The name list of the recommended places with the respective geographic coordinate in UTM and the average distance of each place from Negele are tabulated below.

Name	Northing(M)	Easting(M)	Altitude (M)	Distance From Negele (Km)	Target For
ARDA BURURI	564744	597350	16 m	9	Hand pump
BITATABURA	559678	607440	1501 m	22	Hand pump
BOKOLA	537111	602942	1409 m	47	Hand pump
BURADERA	561160	576079	1248 m	22	Solar pump
DOLCHA	535306	626500	1577 m	54	Hand pump
GARMEDOSIRBA	545952	610403	1554 m	28	Hand pump
HARO	564105	591091	1448 m	2	Hand pump
JIDOLA	533129	593862	1490 m	70	Hand pump
KOBO	533505	604850	1257 m	56	Hand pump
MEDE	544080	597314	1410 m	35	Hand pump
MINGYA	534635	592750	1439 m	75	Hand pump
MUCHO	541103	619591	1600 m	46	Hand pump
NURA AMBA	545829	604140	1510m	27	Hand pump
SHISHU	555376	618035	1430 m	42	Hand pump
SIRBA	539735	612100	1506 m	39	Hand pump
TULADELAN	548776	580997	1295 m	24	Hand pump
WEFE	566135	590326	1548 m	3	Solar pump

Table-18

The geophysical survey carried out in Garmedo Sirba shows very complicated layering, so it is recommendable to give less priority for the area. In all others the depth of the wells expected to be in the range of 4m and 15m. It is recommendable to follow attentively the actual layer encountered per specified depth during excavation work and to compare it with the pre established geoelectrical layering models for areas where geophysical surveys were conducted. For the others, where the geophysical survey were not conducted, the extent of the excavation work must be decided based on the rock layers encountering per specific depth, but the supervisor must remember that the shallow ground aquifer system of the area is set from either by deposited materials or from the weathering and fracturing of basement rocks in the top most part, or from the combination both.

ANNEX

Schlumberger Array

BuraDHera-1

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	8.810	1.000	8.810	1.000
1.250	6.077	1.250	6.077	1.000
1.600	3.517	1.600	3.517	1.000
2.000	3.119	2.000	3.119	1.000
2.500	2.577	2.500	2.577	1.000
3.000	2.421	3.000	1.997	1.000
3.000	1.574	3.000	1.997	1.000
4.000	2.038	4.000	2.038	1.000
5.000	2.053	5.000	2.053	1.000
6.500	2.252	6.500	2.252	1.000
8.000	2.291	8.000	2.291	1.000
10.000	2.394	10.000	2.547	1.000
10.000	2.700	10.000	2.547	1.000
12.500	2.970	12.500	2.970	1.000
16.000	3.597	16.000	3.597	1.000
20.000	4.253	20.000	4.253	1.000
25.000	5.570	25.000	5.570	1.000
30.000	8.045	30.000	7.072	1.000
30.000	6.098	30.000	7.072	1.000
40.000	8.338	40.000	8.473	1.000
40.000	8.608	40.000	8.473	1.000
50.000	10.295	50.000	10.295	1.000
65.000	12.509	65.000	12.509	1.000
80.000	11.448	80.000	11.448	1.000
100.000	18.005	100.000	18.005	1.000
125.000	18.736	125.000	18.736	1.000
160.000	30.835	160.000	30.835	1.000

Schlumberger Array

Bura Dhera2

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	12.500	1.000	12.500	1.000
1.250	7.600	1.250	7.600	1.000
1.600	5.100	1.600	5.100	1.000
2.000	3.600	2.000	3.600	1.000
2.500	2.600	2.500	2.600	1.000
3.000	2.000	3.000	2.000	1.000
4.000	1.200	4.000	1.200	1.000
5.000	1.000	5.000	1.000	1.000
6.500	0.800	6.500	0.800	1.000

8.000	0.800	8.000	0.800	1.000
10.000	1.000	10.000	1.000	1.000
12.500	1.200	12.500	1.200	1.000
16.000	1.350	16.000	1.350	1.000
20.000	1.600	20.000	1.600	1.000
25.000	2.000	25.000	2.000	1.000
30.000	2.800	30.000	2.800	1.000
40.000	3.200	40.000	3.200	1.000
50.000	4.600	50.000	4.600	1.000
65.000	7.000	65.000	7.000	1.000
80.000	9.500	80.000	9.500	1.000
100.000	10.400	100.000	10.400	1.000
125.000	20.000	125.000	20.000	1.000
160.000	32.000	160.000	32.000	1.000
200.000	44.000	200.000	44.000	1.000
250.000	65.000	250.000	65.000	1.000

Schlumberger Array

Bura Dhera3

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	18.654	1.000	18.654	1.000
1.250	15.431	1.250	15.431	1.000
1.600	13.897	1.600	13.897	1.000
2.000	10.846	2.000	10.846	1.000
2.500	8.467	2.500	8.467	1.000
3.000	5.847	3.000	6.566	1.000
3.000	6.582	3.000	6.566	1.000
4.000	6.000	4.000	5.012	1.000
5.000	3.900	5.000	3.900	1.000
6.500	2.252	6.500	2.252	1.000
8.000	1.900	8.000	1.900	1.000
10.000	2.380	10.000	2.034	1.000
10.000	1.688	10.000	2.034	1.000
12.500	2.430	12.500	2.430	1.000
16.000	8.543	16.000	8.543	1.000
20.000	3.534	20.000	3.534	1.000
25.000	5.554	25.000	5.554	1.000
30.000	8.045	30.000	6.807	1.000
30.000	5.568	30.000	6.807	1.000
40.000	11.477	40.000	10.793	1.000
40.000	10.110	40.000	10.793	1.000
50.000	14.707	50.000	14.707	1.000
65.000	20.071	65.000	20.071	1.000
80.000	30.456	80.000	30.456	1.000

100.000	35.804	100.000	33.982	1.000
100.000	32.161	100.000	33.982	1.000
125.000	56.052	125.000	51.046	1.000
125.000	46.041	125.000	51.046	1.000
160.000	67.253	160.000	67.253	1.000
160.000	67.253	160.000	67.253	1.000
200.000	106.332	200.000	106.332	1.000
250.000	145.230	250.000	145.230	1.000

Schlumberger Array

Mucho-1

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.500	24.806	1.500	24.806	1.000
2.100	20.784	2.100	20.784	1.000
3.000	17.022	3.000	17.022	1.000
4.200	15.051	4.200	15.051	1.000
6.000	14.453	6.000	14.453	1.000
9.000	15.260	9.000	15.260	1.000
13.500	19.800	13.500	19.800	1.000
20.000	26.625	20.000	32.303	1.000
20.000	37.980	20.000	32.303	1.000
30.000	47.164	30.000	51.725	1.000
30.000	56.286	30.000	51.725	1.000
45.000	75.440	45.000	75.440	1.000
66.000	114.360	66.000	114.360	1.000
100.000	164.530	100.000	164.530	1.000
150.000	326.260	150.000	326.260	1.000
220.000	429.943	220.000	429.943	1.000

Schlumberger Array

Mucho-2

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.500	42.211	1.500	42.211	1.000
2.100	38.200	2.100	38.200	1.000
3.000	34.897	3.000	34.897	1.000
4.200	34.899	4.200	34.899	1.000
6.000	36.725	6.000	36.725	1.000
9.000	40.919	9.000	40.919	1.000

13.500	53.482	13.500	53.482	1.000
20.000	74.875	20.000	75.796	1.000
20.000	76.716	20.000	75.796	1.000
30.000	101.597	30.000	102.778	1.000
30.000	103.960	30.000	102.778	1.000
45.000	131.040	45.000	131.040	1.000
66.000	176.280	66.000	176.280	1.000
100.000	268.550	100.000	268.550	1.000
150.000	413.952	150.000	413.952	1.000
220.000	676.620	220.000	676.620	1.000

Schlumberger Array

Haro-1

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	21.170	1.000	21.170	1.000
1.250	15.050	1.250	15.050	1.000
1.600	10.250	1.600	10.250	1.000
2.000	6.800	2.000	7.680	1.000
2.500	6.790	2.500	7.242	1.000
3.000	7.563	3.000	7.301	1.000
3.000	7.040	3.000	7.301	1.000
4.000	7.870	4.000	7.870	1.000
5.000	8.500	5.000	8.500	1.000
6.500	9.760	6.500	9.760	1.000
8.000	10.660	8.000	10.660	1.000
10.000	11.340	10.000	11.155	1.000
10.000	10.970	10.000	11.155	1.000
12.500	12.960	12.500	12.960	1.000
16.000	16.190	16.000	16.190	1.000
20.000	19.140	20.000	19.140	1.000
25.000	24.510	25.000	24.510	1.000
30.000	28.960	30.000	30.685	1.000
30.000	32.410	30.000	30.685	1.000
40.000	37.300	40.000	39.960	1.000
40.000	42.620	40.000	39.960	1.000
50.000	58.660	50.000	58.660	1.000
65.000	82.550	65.000	82.550	1.000
80.000	106.590	80.000	106.590	1.000
100.000	137.250	100.000	137.250	1.000
125.000	187.380	125.000	187.380	1.000
160.000	245.970	160.000	245.970	1.000

Schlumberger Array

Haro-2

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	16.620	1.000	16.620	1.000
1.250	15.130	1.250	15.130	1.000
1.600	13.620	1.600	13.620	1.000
2.000	13.080	2.000	13.080	1.000
2.500	12.920	2.500	12.920	1.000
3.000	13.230	3.000	13.085	1.000
3.000	12.940	3.000	13.085	1.000
4.000	14.770	4.000	14.770	1.000
5.000	17.500	5.000	17.500	1.000
6.500	21.070	6.500	21.070	1.000
8.000	24.050	8.000	24.050	1.000
10.000	27.530	10.000	25.020	1.000
10.000	22.510	10.000	25.020	1.000
12.500	27.350	12.500	27.350	1.000
16.000	33.370	16.000	33.370	1.000
20.000	41.940	20.000	41.940	1.000
25.000	53.620	25.000	53.620	1.000
30.000	67.780	30.000	61.828	1.000
30.000	55.876	30.000	61.828	1.000
40.000	94.960	40.000	87.895	1.000
40.000	80.830	40.000	87.895	1.000
50.000	102.950	50.000	102.950	1.000
65.000	137.990	65.000	137.990	1.000
80.000	175.620	80.000	175.620	1.000
100.000	227.410	100.000	227.410	1.000

Schlumberger Array

Haro-3

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	21.170	1.000	21.170	1.000
1.250	15.050	1.250	15.050	1.000
1.600	10.250	1.600	10.250	1.000
2.000	6.800	2.000	7.739	1.000
2.500	6.790	2.500	7.162	1.000
3.000	7.563	3.000	7.301	1.000
3.000	7.040	3.000	7.301	1.000
4.000	7.870	4.000	7.870	1.000
5.000	8.500	5.000	8.500	1.000
6.500	9.760	6.500	9.760	1.000
8.000	10.660	8.000	10.660	1.000
10.000	11.340	10.000	11.808	1.000
10.000	10.970	10.000	11.808	1.000
12.500	12.960	12.500	14.504	1.000

16.000	16.190	16.000	18.119	1.000
20.000	19.140	20.000	21.420	1.000
25.000	24.510	25.000	27.430	1.000
30.000	28.960	30.000	32.410	1.000
30.000	32.410	30.000	32.410	1.000
40.000	37.300	40.000	39.960	1.000
40.000	42.620	40.000	39.960	1.000
50.000	58.660	50.000	58.660	1.000
65.000	82.550	65.000	82.550	1.000
80.000	106.590	80.000	106.590	1.000
100.000	137.250	100.000	137.250	1.000
125.000	187.380	125.000	187.380	1.000
160.000	245.970	160.000	245.970	1.000

Schlumberger Array

Arda Bururi1

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	28.850	1.000	28.850	1.000
1.250	27.110	1.250	27.110	1.000
1.600	22.690	1.600	22.690	1.000
2.000	20.120	2.000	20.120	1.000
2.500	18.480	2.500	18.480	1.000
3.000	17.520	3.000	16.900	1.000
3.000	16.280	3.000	16.900	1.000
4.000	14.230	4.000	14.230	1.000
5.000	13.280	5.000	13.280	1.000
6.500	12.980	6.500	12.980	1.000
8.000	13.170	8.000	13.170	1.000
10.000	14.060	10.000	12.800	1.000
10.000	11.540	10.000	12.800	1.000
12.500	12.130	12.500	12.130	1.000
16.000	13.300	16.000	13.300	1.000
20.000	16.640	20.000	16.640	1.000
25.000	19.380	25.000	19.380	1.000
30.000	23.120	30.000	24.250	1.000
30.000	25.380	30.000	24.250	1.000
40.000	35.140	40.000	36.005	1.000
40.000	36.870	40.000	36.005	1.000
50.000	46.400	50.000	46.400	1.000
65.000	68.930	65.000	68.930	1.000
80.000	85.470	80.000	85.470	1.000
100.000	115.700	100.000	115.700	1.000

Schlumberger Array

Arda Bururi2

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	25.450	1.000	25.450	1.000
1.250	22.040	1.250	22.040	1.000
1.600	20.830	1.600	20.830	1.000
2.000	18.590	2.000	18.590	1.000
2.500	15.000	2.500	15.000	1.000
3.000	13.300	3.000	14.710	1.000
3.000	16.120	3.000	14.710	1.000
4.000	14.270	4.000	14.270	1.000
5.000	13.170	5.000	13.170	1.000
6.500	12.250	6.500	12.250	1.000
8.000	11.650	8.000	11.650	1.000
10.000	12.790	10.000	11.995	1.000
10.000	11.200	10.000	11.995	1.000
12.500	12.130	12.500	12.130	1.000
16.000	12.390	16.000	12.390	1.000
20.000	15.190	20.000	15.190	1.000
25.000	19.320	25.000	19.320	1.000
30.000	22.990	30.000	23.375	1.000
30.000	23.760	30.000	23.375	1.000
40.000	29.280	40.000	32.600	1.000
40.000	35.920	40.000	32.600	1.000
50.000	44.900	50.000	44.900	1.000
65.000	63.820	65.000	63.820	1.000
80.000	81.820	80.000	81.820	1.000
100.000	91.880	100.000	91.880	1.000

Schlumberger Array

Bitata Bura-1

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.500	29.756	1.500	29.756	1.000
2.100	16.554	2.100	16.554	1.000
3.000	13.200	3.000	13.200	1.000
4.200	8.808	4.200	8.808	1.000
6.000	7.914	6.000	8.633	1.000
9.000	11.506	9.000	11.506	1.000
13.500	17.103	13.500	17.103	1.000
20.000	35.000	20.000	28.793	1.000
20.000	22.586	20.000	28.793	1.000
30.000	70.184	30.000	51.530	1.000

30.000	37.380	30.000	51.530	1.000
45.000	60.944	45.000	60.944	1.000
66.000	94.016	66.000	94.016	1.000
100.000	186.806	100.000	153.209	1.000
150.000	282.240	150.000	250.000	1.000
220.000	504.000	220.000	400.000	1.000

Schlumberger Array

Bitata Bura-2

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.500	46.786	1.500	46.786	1.000
2.100	34.554	2.100	34.554	1.000
3.000	24.200	3.000	24.200	1.000
4.200	15.808	4.200	15.808	1.000
6.000	13.153	6.000	13.153	1.000
9.000	14.427	9.000	14.427	1.000
13.500	18.018	13.500	18.018	1.000
20.000	29.125	20.000	24.188	1.000
20.000	19.251	20.000	24.188	1.000
30.000	32.098	30.000	32.098	1.000
30.000	32.098	30.000	32.098	1.000
45.000	54.236	45.000	54.236	1.000
66.000	89.722	66.000	89.722	1.000
100.000	146.196	100.000	146.196	1.000
150.000	342.804	150.000	252.101	1.000
220.000	432.180	220.000	420.853	1.000

Schlumberger Array

Bitata Bura-3

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	285.680	1.000	285.680	1.000
1.250	196.700	1.250	196.700	1.000
1.600	147.320	1.600	147.320	1.000
2.000	135.830	2.000	135.830	1.000
2.500	120.630	2.500	120.630	1.000
3.000	116.400	3.000	109.715	1.000
3.000	103.030	3.000	109.715	1.000
4.000	85.590	4.000	85.590	1.000

5.000	74.900	5.000	74.900	1.000
6.500	76.870	6.500	76.870	1.000
8.000	76.690	8.000	76.690	1.000
10.000	77.990	10.000	77.460	1.000
10.000	76.930	10.000	77.460	1.000
12.500	72.300	12.500	72.300	1.000
16.000	51.360	16.000	51.360	1.000
20.000	53.670	20.000	53.670	1.000
25.000	60.890	25.000	60.890	1.000
30.000	77.020	30.000	70.540	1.000
30.000	64.060	30.000	70.540	1.000
40.000	103.150	40.000	94.625	1.000
40.000	86.100	40.000	94.625	1.000
50.000	112.520	50.000	112.520	1.000
65.000	159.980	65.000	159.980	1.000
80.000	192.950	80.000	192.950	1.000
100.000	233.430	100.000	233.430	1.000

Schlumberger Array

Bitata Bura-4

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	160.640	1.000	160.640	1.000
1.250	101.760	1.250	101.760	1.000
1.600	67.130	1.600	67.130	1.000
2.000	56.750	2.000	56.750	1.000
2.500	41.410	2.500	41.410	1.000
3.000	31.710	3.000	29.226	1.000
3.000	26.743	3.000	29.226	1.000
4.000	22.840	4.000	22.840	1.000
5.000	18.850	5.000	18.850	1.000
6.500	17.380	6.500	17.380	1.000
8.000	16.530	8.000	16.530	1.000
10.000	15.580	10.000	15.917	1.000
10.000	12.360	10.000	15.917	1.000
12.500	12.520	12.500	18.000	1.000
16.000	16.010	16.000	21.000	1.000
20.000	19.920	20.000	25.000	1.000
25.000	28.310	25.000	34.096	1.000
30.000	35.470	30.000	42.720	1.000
30.000	42.720	30.000	42.720	1.000
40.000	51.630	40.000	55.510	1.000
40.000	59.390	40.000	55.510	1.000
50.000	80.920	50.000	80.920	1.000

65.000	121.930	65.000	121.930	1.000
80.000	139.720	80.000	139.720	1.000
100.000	160.040	100.000	160.040	1.000

Schlumberger Array

Bitata Bura-5

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	27.330	1.000	27.330	1.000
1.250	26.520	1.250	26.520	1.000
1.600	18.480	1.600	18.480	1.000
2.000	16.280	2.000	16.280	1.000
2.500	13.760	2.500	13.760	1.000
3.000	11.230	3.000	11.245	1.000
3.000	11.260	3.000	11.245	1.000
4.000	8.890	4.000	8.890	1.000
5.000	9.280	5.000	9.280	1.000
6.500	10.720	6.500	10.720	1.000
8.000	12.430	8.000	12.430	1.000
10.000	15.180	10.000	15.080	1.000
10.000	14.980	10.000	15.080	1.000
12.500	19.570	12.500	19.570	1.000
16.000	26.150	16.000	26.150	1.000
20.000	33.180	20.000	33.180	1.000
25.000	44.330	25.000	44.330	1.000
30.000	54.190	30.000	48.280	1.000
30.000	42.370	30.000	48.280	1.000
40.000	73.200	40.000	66.380	1.000
40.000	59.560	40.000	66.380	1.000
50.000	68.840	50.000	68.840	1.000
65.000	94.460	65.000	94.460	1.000
80.000	108.780	80.000	108.780	1.000
100.000	133.970	100.000	133.970	1.000

Schlumberger Array

Bitata Bura-6

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	108.780	1.000	108.780	1.000
1.250	93.650	1.250	93.650	1.000
1.600	77.900	1.600	77.900	1.000
2.000	62.460	2.000	62.460	1.000

2.500	44.190	2.500	44.190	1.000
3.000	38.640	3.000	34.500	1.000
3.000	30.360	3.000	34.500	1.000
4.000	25.470	4.000	25.470	1.000
5.000	20.530	5.000	20.530	1.000
6.500	14.970	6.500	14.970	1.000
8.000	14.670	8.000	14.670	1.000
10.000	16.345	10.000	17.847	1.000
10.000	19.350	10.000	17.847	1.000
12.500	22.470	12.500	22.470	1.000
16.000	27.830	16.000	27.830	1.000
20.000	32.330	20.000	32.330	1.000
25.000	41.820	25.000	41.820	1.000
30.000	49.120	30.000	57.270	1.000
30.000	65.420	30.000	57.270	1.000
40.000	66.950	40.000	79.665	1.000
40.000	92.380	40.000	79.665	1.000
50.000	111.910	50.000	111.910	1.000
65.000	137.460	65.000	137.460	1.000
80.000	162.700	80.000	162.700	1.000
100.000	200.950	100.000	200.950	1.000

Schlumberger Array

Bitata Bura-7

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	26.800	1.000	26.800	1.000
1.250	24.150	1.250	24.150	1.000
1.600	22.500	1.600	22.500	1.000
2.000	19.550	2.000	19.550	1.000
2.500	16.090	2.500	16.090	1.000
3.000	12.100	3.000	13.235	1.000
3.000	14.370	3.000	13.235	1.000
4.000	11.000	4.000	11.000	1.000
5.000	9.000	5.000	9.000	1.000
6.500	7.800	6.500	8.500	1.000
8.000	8.420	8.000	9.000	1.000
10.000	10.200	10.000	10.955	1.000
10.000	11.710	10.000	10.955	1.000
12.500	14.670	12.500	14.670	1.000
16.000	19.450	16.000	19.450	1.000
20.000	25.000	20.000	25.000	1.000
25.000	33.000	25.000	33.000	1.000

30.000	40.340	30.000	39.805	1.000
30.000	39.270	30.000	39.805	1.000
40.000	54.670	40.000	53.890	1.000
40.000	53.110	40.000	53.890	1.000
50.000	64.900	50.000	64.900	1.000
65.000	75.500	65.000	75.500	1.000
80.000	88.060	80.000	88.060	1.000
100.000	102.300	100.000	102.300	1.000

Schlumberger Array

Bitata Bura-8

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	139.170	1.000	139.170	1.000
1.250	102.000	1.250	102.000	1.000
1.600	85.390	1.600	85.390	1.000
2.000	76.220	2.000	76.220	1.000
2.500	65.430	2.500	65.430	1.000
3.000	55.700	3.000	56.170	1.000
3.000	56.640	3.000	56.170	1.000
4.000	44.720	4.000	44.720	1.000
5.000	36.280	5.000	36.280	1.000
6.500	32.460	6.500	32.460	1.000
8.000	25.650	8.000	25.650	1.000
10.000	23.470	10.000	23.470	1.000
10.000	21.040	10.000	23.470	1.000
12.500	22.270	12.500	24.842	1.000
16.000	24.420	16.000	27.240	1.000
20.000	33.500	20.000	37.369	1.000
25.000	43.700	25.000	48.747	1.000
30.000	55.020	30.000	57.437	1.000
30.000	53.500	30.000	57.437	1.000
40.000	76.400	40.000	76.400	1.000
50.000	101.770	50.000	101.770	1.000
65.000	140.910	65.000	140.910	1.000
80.000	165.110	80.000	165.110	1.000
100.000	192.610	100.000	192.610	1.000

Schlumberger Array

Bitata Bura-9

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	183.320	1.000	183.320	1.000

1.250	177.310	1.250	177.310	1.000
1.600	176.260	1.600	176.260	1.000
2.000	162.670	2.000	162.670	1.000
2.500	148.440	2.500	148.440	1.000
3.000	120.250	3.000	124.780	1.000
3.000	129.310	3.000	124.780	1.000
4.000	105.770	4.000	105.770	1.000
5.000	70.640	5.000	70.640	1.000
6.500	42.020	6.500	42.020	1.000
8.000	31.780	8.000	31.780	1.000
10.000	28.810	10.000	30.190	1.000
10.000	31.570	10.000	30.190	1.000
12.500	34.220	12.500	34.220	1.000
16.000	41.600	16.000	41.600	1.000
20.000	49.190	20.000	49.190	1.000
25.000	59.340	25.000	59.340	1.000
30.000	71.200	30.000	72.800	1.000
30.000	74.400	30.000	72.800	1.000
40.000	86.570	40.000	88.485	1.000
40.000	90.400	40.000	88.485	1.000
50.000	109.150	50.000	109.150	1.000
65.000	133.350	65.000	133.350	1.000

Schlumberger Array

Bitata Bura-10

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	112.930	1.000	112.930	1.000
1.250	118.900	1.250	118.900	1.000
1.600	106.340	1.600	106.340	1.000
2.000	105.890	2.000	105.890	1.000
2.500	100.170	2.500	100.170	1.000
3.000	90.790	3.000	89.825	1.000
3.000	88.860	3.000	89.825	1.000
4.000	73.050	4.000	73.050	1.000
5.000	63.420	5.000	63.420	1.000
6.500	51.580	6.500	51.580	1.000
8.000	40.200	8.000	40.200	1.000
10.000	40.810	10.000	38.145	1.000
10.000	35.480	10.000	38.145	1.000
12.500	37.750	12.500	37.750	1.000
16.000	46.580	16.000	46.580	1.000
20.000	57.040	20.000	57.040	1.000
25.000	68.340	25.000	68.340	1.000
30.000	80.480	30.000	74.010	1.000

30.000	67.540	30.000	74.010	1.000
40.000	103.890	40.000	96.670	1.000
40.000	89.450	40.000	96.670	1.000
50.000	112.100	50.000	112.100	1.000
65.000	150.970	65.000	150.970	1.000
80.000	183.790	80.000	183.790	1.000

Schlumberger Array

Shishu-1

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	276.200	1.000	276.200	1.000
1.250	274.480	1.250	274.480	1.000
1.600	217.080	1.600	217.000	1.000
2.000	169.620	2.000	190.000	1.000
2.500	169.620	2.500	169.620	1.000
3.000	149.190	3.000	152.715	1.000
3.000	156.240	3.000	152.715	1.000
4.000	108.800	4.000	108.800	1.000
5.000	69.680	5.000	69.680	1.000
6.500	41.750	6.500	41.750	1.000
8.000	32.150	8.000	32.150	1.000
10.000	30.360	10.000	29.285	1.000
10.000	28.210	10.000	29.285	1.000
12.500	25.010	12.500	25.010	1.000
16.000	24.700	16.000	24.700	1.000
20.000	28.130	20.000	28.130	1.000
25.000	32.870	25.000	32.870	1.000
30.000	39.290	30.000	39.480	1.000
30.000	39.670	30.000	39.480	1.000
40.000	52.700	40.000	53.290	1.000
40.000	53.880	40.000	53.290	1.000
50.000	65.660	50.000	65.660	1.000
65.000	84.250	65.000	84.250	1.000
80.000	104.590	80.000	104.590	1.000
100.000	133.580	100.000	133.580	1.000

Schlumberger Array

Shishu-2

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	130.060	1.000	130.060	1.000

1.250	120.120	1.250	120.120	1.000
1.600	101.020	1.600	101.020	1.000
2.000	92.380	2.000	92.380	1.000
2.500	71.300	2.500	71.300	1.000
3.000	63.200	3.000	64.485	1.000
3.000	65.770	3.000	64.485	1.000
4.000	45.900	4.000	45.900	1.000
5.000	36.110	5.000	36.110	1.000
6.500	27.490	6.500	27.490	1.000
8.000	23.630	8.000	23.630	1.000
10.000	21.860	10.000	21.490	1.000
10.000	21.120	10.000	21.490	1.000
12.500	19.780	12.500	19.780	1.000
16.000	20.130	16.000	20.130	1.000
20.000	21.640	20.000	21.640	1.000
25.000	23.800	25.000	23.800	1.000
30.000	26.200	30.000	27.270	1.000
30.000	28.340	30.000	27.270	1.000
40.000	32.110	40.000	33.495	1.000
40.000	34.880	40.000	33.495	1.000
50.000	43.270	50.000	43.270	1.000
65.000	56.000	65.000	56.000	1.000
80.000	77.470	80.000	77.470	1.000
100.000	103.220	100.000	103.220	1.000

Schlumberger Array

Shishu-3

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	69.950	1.000	69.950	1.000
1.250	61.890	1.250	61.890	1.000
1.600	46.310	1.600	46.310	1.000
2.000	38.170	2.000	38.170	1.000
2.500	30.680	2.500	30.680	1.000
3.000	26.240	3.000	22.180	1.000
3.000	18.120	3.000	22.180	1.000
4.000	11.640	4.000	11.640	1.000
5.000	9.040	5.000	9.040	1.000
6.500	4.970	6.500	4.970	1.000
8.000	3.780	8.000	3.780	1.000
10.000	3.560	10.000	3.290	1.000
10.000	3.020	10.000	3.290	1.000
12.500	2.420	12.500	2.420	1.000
16.000	2.230	16.000	2.230	1.000

20.000	2.110	20.000	2.110	1.000
25.000	2.210	25.000	2.210	1.000
30.000	1.600	30.000	2.560	1.000
30.000	3.520	30.000	2.560	1.000
40.000	2.850	40.000	3.265	1.000
40.000	3.680	40.000	3.265	1.000
50.000	4.370	50.000	4.370	1.000
65.000	7.460	65.000	7.460	1.000
80.000	7.570	80.000	7.570	1.000
100.000	11.867	100.000	11.867	1.000

Schlumberger Array

Shishu-4

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	187.054	1.000	187.054	1.000
1.250	176.810	1.250	176.810	1.000
1.600	147.280	1.600	147.280	1.000
2.000	151.270	2.000	151.270	1.000
2.500	128.860	2.500	128.860	1.000
3.000	106.060	3.000	95.255	1.000
3.000	84.450	3.000	95.255	1.000
4.000	66.320	4.000	66.320	1.000
5.000	51.620	5.000	51.620	1.000
6.500	41.660	6.500	41.660	1.000
8.000	30.750	8.000	30.750	1.000
10.000	26.800	10.000	27.200	1.000
10.000	27.600	10.000	27.200	1.000
12.500	26.120	12.500	26.120	1.000
16.000	27.350	16.000	27.350	1.000
20.000	28.980	20.000	28.980	1.000
25.000	32.210	25.000	32.210	1.000
30.000	36.790	30.000	35.765	1.000
30.000	34.740	30.000	35.765	1.000
40.000	44.210	40.000	44.210	1.000
50.000	53.950	50.000	53.950	1.000
65.000	72.140	65.000	72.140	1.000
80.000	87.310	80.000	87.310	1.000
100.000	136.850	100.000	136.850	1.000

Schlumberger Array

Shishu-5

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	168.600	1.000	168.600	1.000

1.250	155.300	1.250	155.300	1.000
1.600	125.700	1.600	125.700	1.000
2.000	121.340	2.000	121.340	1.000
2.500	104.650	2.500	104.650	1.000
3.000	96.780	3.000	86.960	1.000
3.000	77.140	3.000	86.960	1.000
4.000	50.170	4.000	50.170	1.000
5.000	37.060	5.000	37.060	1.000
6.500	23.080	6.500	23.080	1.000
8.000	18.300	8.000	18.300	1.000
10.000	16.760	10.000	16.925	1.000
10.000	17.090	10.000	16.925	1.000
12.500	16.250	12.500	16.250	1.000
16.000	18.500	16.000	18.500	1.000
20.000	19.900	20.000	19.900	1.000
25.000	22.340	25.000	22.340	1.000
30.000	27.430	30.000	27.800	1.000
30.000	28.170	30.000	27.800	1.000
40.000	34.530	40.000	35.845	1.000
40.000	37.160	40.000	35.845	1.000
50.000	45.160	50.000	45.160	1.000
65.000	60.210	65.000	60.210	1.000
80.000	76.160	80.000	76.160	1.000
100.000	95.750	100.000	95.750	1.000

Schlumberger Array

Sirba-1

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.500	63.428	1.500	63.428	1.000
2.100	50.280	2.100	50.280	1.000
3.000	37.150	3.000	37.150	1.000
4.200	34.899	4.200	34.899	1.000
6.000	37.742	6.000	37.742	1.000
9.000	42.469	9.000	42.469	1.000
13.500	53.310	13.500	53.310	1.000
20.000	69.375	20.000	63.135	1.000
20.000	56.894	20.000	63.135	1.000
30.000	56.894	30.000	67.432	1.000
30.000	77.970	30.000	67.432	1.000
45.000	99.840	45.000	99.840	1.000
66.000	129.046	66.000	129.046	1.000
100.000	192.570	100.000	192.570	1.000
150.000	261.660	150.000	261.660	1.000
220.000	375.480	220.000	375.480	1.000

Schlumberger Array

Sirba-2

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.500	40.255	1.500	40.255	1.000
2.100	35.683	2.100	35.683	1.000
3.000	30.704	3.000	30.704	1.000
4.200	37.689	4.200	37.689	1.000
6.000	52.997	6.000	52.997	1.000
9.000	56.896	9.000	56.896	1.000
13.500	81.400	13.500	81.400	1.000
20.000	114.500	20.000	99.950	1.000
20.000	85.400	20.000	99.950	1.000
30.000	166.970	30.000	145.975	1.000
30.000	124.980	30.000	145.975	1.000
45.000	145.960	45.000	145.960	1.000
66.000	190.691	66.000	190.691	1.000
100.000	264.360	100.000	264.360	1.000
150.000	311.060	150.000	311.060	1.000
220.000	446.040	220.000	446.040	1.000

Schlumberger Array

Jidola-1

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	52.190	1.000	52.190	1.000
1.250	57.260	1.250	57.260	1.000
1.600	58.360	1.600	58.360	1.000
2.000	54.630	2.000	54.630	1.000
2.500	49.670	2.500	49.670	1.000
3.000	46.610	3.000	47.840	1.000
3.000	49.070	3.000	47.840	1.000
4.000	38.680	4.000	38.680	1.000
5.000	32.600	5.000	32.600	1.000
6.500	24.730	6.500	24.730	1.000
8.000	22.210	8.000	22.210	1.000
10.000	19.810	10.000	18.925	1.000
10.000	18.040	10.000	18.925	1.000
12.500	19.340	12.500	19.340	1.000
16.000	25.400	16.000	25.400	1.000
20.000	33.610	20.000	33.610	1.000
25.000	46.070	25.000	46.070	1.000
30.000	58.430	30.000	57.305	1.000
30.000	56.180	30.000	57.305	1.000
40.000	92.610	40.000	90.225	1.000

40.000	87.840	40.000	90.225	1.000
50.000	119.820	50.000	119.820	1.000
65.000	166.550	65.000	166.550	1.000
80.000	222.720	80.000	222.720	1.000
100.000	300.960	100.000	300.960	1.000
100.000	300.960	100.000	300.960	1.000

Schlumberger Array

Jidola-2

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	114.220	1.000	114.220	1.000
1.250	102.900	1.250	102.900	1.000
1.600	77.090	1.600	77.090	1.000
2.000	71.140	2.000	71.140	1.000
2.500	64.830	2.500	64.830	1.000
3.000	62.810	3.000	59.500	1.000
3.000	56.190	3.000	59.500	1.000
4.000	47.790	4.000	47.790	1.000
5.000	41.090	5.000	41.090	1.000
6.500	40.630	6.500	40.630	1.000
8.000	43.130	8.000	43.130	1.000
10.000	48.290	10.000	46.315	1.000
10.000	44.340	10.000	46.315	1.000
12.500	52.450	12.500	52.450	1.000
16.000	64.580	16.000	64.580	1.000
20.000	75.300	20.000	75.300	1.000
25.000	89.000	25.000	89.000	1.000
30.000	107.430	30.000	107.140	1.000
30.000	106.850	30.000	107.140	1.000
40.000	136.830	40.000	136.625	1.000
40.000	136.420	40.000	136.625	1.000
50.000	169.120	50.000	169.120	1.000
65.000	232.830	65.000	232.830	1.000
80.000	304.240	80.000	304.240	1.000
100.000	381.410	100.000	381.410	1.000

Schlumberger Array

Jidola-3

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	71.350	1.000	71.350	1.000
1.250	63.600	1.250	63.600	1.000
1.600	44.180	1.600	44.180	1.000
2.000	30.900	2.000	30.900	1.000

2.500	21.500	2.500	21.500	1.000
3.000	17.900	3.000	18.525	1.000
3.000	19.150	3.000	18.525	1.000
4.000	15.030	4.000	15.030	1.000
5.000	14.620	5.000	14.620	1.000
6.500	16.300	6.500	16.300	1.000
8.000	19.750	8.000	19.750	1.000
10.000	24.890	10.000	24.120	1.000
10.000	23.350	10.000	24.120	1.000
12.500	30.860	12.500	30.860	1.000
16.000	42.670	16.000	42.670	1.000
20.000	56.420	20.000	56.420	1.000
25.000	71.620	25.000	71.620	1.000
30.000	87.020	30.000	86.135	1.000
30.000	85.250	30.000	86.135	1.000
40.000	108.340	40.000	109.000	1.000
40.000	109.660	40.000	109.000	1.000
50.000	127.210	50.000	127.210	1.000
65.000	160.830	65.000	160.830	1.000
80.000	198.130	80.000	198.130	1.000
100.000	261.850	100.000	261.850	1.000

Schlumberger Array

Minya-1

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	71.080	1.000	71.080	1.000
1.250	53.390	1.250	53.390	1.000
1.600	37.810	1.600	37.810	1.000
2.000	33.800	2.000	33.800	1.000
2.500	35.830	2.500	33.000	1.000
3.000	38.240	3.000	34.325	1.000
3.000	30.410	3.000	34.325	1.000
4.000	31.670	4.000	31.670	1.000
5.000	32.780	5.000	32.780	1.000
6.500	36.040	6.500	36.040	1.000
8.000	38.620	8.000	38.620	1.000
10.000	41.770	10.000	40.235	1.000
10.000	38.700	10.000	40.235	1.000
12.500	44.110	12.500	44.110	1.000
16.000	52.460	16.000	52.460	1.000
20.000	64.000	20.000	64.000	1.000
25.000	81.290	25.000	81.290	1.000
30.000	94.700	30.000	88.190	1.000

30.000	81.680	30.000	88.190	1.000
40.000	128.080	40.000	119.490	1.000
40.000	110.900	40.000	119.490	1.000
50.000	142.830	50.000	142.830	1.000
65.000	187.270	65.000	187.270	1.000
80.000	239.460	80.000	239.460	1.000
100.000	302.700	100.000	302.700	1.000

Schlumberger Array

Minya-2

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	76.740	1.000	76.740	1.000
1.250	59.380	1.250	59.380	1.000
1.600	31.330	1.600	31.330	1.000
2.000	27.270	2.000	27.270	1.000
2.500	28.190	2.500	28.190	1.000
3.000	29.070	3.000	30.335	1.000
3.000	31.600	3.000	30.335	1.000
4.000	32.420	4.000	32.420	1.000
5.000	33.320	5.000	33.320	1.000
6.500	35.590	6.500	35.590	1.000
8.000	36.900	8.000	36.900	1.000
10.000	40.800	10.000	38.655	1.000
10.000	36.510	10.000	38.655	1.000
12.500	41.340	12.500	41.340	1.000
16.000	49.550	16.000	49.550	1.000
20.000	62.940	20.000	62.940	1.000
25.000	80.730	25.000	80.730	1.000
30.000	100.160	30.000	97.875	1.000
30.000	95.590	30.000	97.875	1.000
40.000	131.760	40.000	129.880	1.000
40.000	128.000	40.000	129.880	1.000

Schlumberger Array

Garmedo Sirba-1

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	109.790	1.000	109.790	1.000
1.250	95.150	1.250	95.150	1.000
1.600	84.830	1.600	89.133	1.000
2.000	85.350	2.000	85.350	1.000
2.500	77.980	2.500	77.980	1.000
3.000	67.020	3.000	67.020	1.000

3.000	67.020	3.000	67.020	1.000
4.000	58.270	4.000	58.270	1.000
5.000	54.550	5.000	54.550	1.000
6.500	51.540	6.500	51.540	1.000
8.000	52.530	8.000	52.530	1.000
10.000	60.870	10.000	57.440	1.000
10.000	54.010	10.000	57.440	1.000
12.500	62.120	12.500	62.120	1.000
16.000	74.190	16.000	74.190	1.000
20.000	93.840	20.000	93.840	1.000
25.000	118.080	25.000	118.080	1.000
30.000	141.600	30.000	136.875	1.000
30.000	132.150	30.000	136.875	1.000
40.000	177.890	40.000	173.490	1.000
40.000	169.090	40.000	173.490	1.000
50.000	195.050	50.000	195.050	1.000
65.000	220.800	65.000	220.800	1.000
80.000	258.870	80.000	258.870	1.000
100.000	293.240	100.000	293.240	1.000

Schlumberger Array

Garmedo Sirba-2

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	92.720	1.000	92.720	1.000
1.250	76.930	1.250	76.930	1.000
1.600	67.760	1.600	67.760	1.000
2.000	67.250	2.000	67.250	1.000
2.500	67.850	2.500	67.850	1.000
3.000	73.100	3.000	68.360	1.000
3.000	63.620	3.000	68.360	1.000
4.000	72.240	4.000	72.240	1.000
5.000	77.650	5.000	77.650	1.000
6.500	75.520	6.500	75.520	1.000
8.000	81.310	8.000	81.310	1.000
10.000	84.980	10.000	81.585	1.000
10.000	78.190	10.000	81.585	1.000
12.500	81.760	12.500	81.760	1.000
16.000	86.830	16.000	86.830	1.000
20.000	99.100	20.000	99.100	1.000
25.000	109.800	25.000	109.800	1.000
30.000	121.370	30.000	108.810	1.000
30.000	96.250	30.000	108.810	1.000
40.000	158.720	40.000	145.510	1.000
40.000	132.300	40.000	145.510	1.000

50.000	171.090	50.000	171.090	1.000
65.000	216.390	65.000	216.390	1.000
80.000	249.600	80.000	249.600	1.000
100.000	271.640	100.000	271.640	1.000

Schlumberger Array

Garmedo Sirba-3

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	29.910	1.000	29.910	1.000
1.250	21.900	1.250	24.278	1.000
1.600	20.750	1.600	20.750	1.000
2.000	21.460	2.000	21.460	1.000
2.500	21.900	2.500	21.900	1.000
3.000	23.720	3.000	22.245	1.000
3.000	20.770	3.000	22.245	1.000
4.000	23.110	4.000	23.110	1.000
5.000	25.290	5.000	25.290	1.000
6.500	29.350	6.500	29.350	1.000
8.000	34.080	8.000	34.080	1.000
10.000	39.490	10.000	39.210	1.000
10.000	38.930	10.000	39.210	1.000
12.500	44.410	12.500	44.410	1.000
16.000	49.740	16.000	49.740	1.000
20.000	54.180	20.000	54.180	1.000
25.000	61.620	25.000	61.620	1.000
30.000	71.210	30.000	73.795	1.000
30.000	76.380	30.000	73.795	1.000
40.000	86.570	40.000	90.340	1.000
40.000	94.110	40.000	90.340	1.000
50.000	116.520	50.000	116.520	1.000
65.000	148.450	65.000	148.450	1.000
80.000	172.000	80.000	172.000	1.000
100.000	198.050	100.000	198.050	1.000

Schlumberger Array

Garmedo Sirba-4

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	75.730	1.000	75.730	1.000
1.250	61.250	1.250	61.250	1.000
1.600	56.180	1.600	56.180	1.000
2.000	58.270	2.000	58.270	1.000
2.500	55.290	2.500	55.290	1.000

3.000	54.210	3.000	57.310	1.000
3.000	60.410	3.000	57.310	1.000
4.000	53.540	4.000	53.540	1.000
5.000	53.250	5.000	53.250	1.000
6.500	52.990	6.500	52.990	1.000
8.000	52.990	8.000	52.990	1.000
10.000	58.990	10.000	53.920	1.000
10.000	48.850	10.000	53.920	1.000
12.500	57.200	12.500	57.200	1.000
16.000	67.120	16.000	67.120	1.000
20.000	77.220	20.000	77.220	1.000
25.000	91.010	25.000	91.010	1.000
30.000	101.420	30.000	101.420	1.000
30.000	102.250	30.000	101.420	1.000
40.000	112.870	40.000	112.507	1.000
40.000	113.060	40.000	112.507	1.000
50.000	124.260	50.000	124.260	1.000
65.000	143.830	65.000	143.830	1.000
80.000	172.790	80.000	172.790	1.000

Schlumberger Array

Garmedo Sirba-5

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	26.800	1.000	26.800	1.000
1.250	24.150	1.250	24.150	1.000
1.600	22.500	1.600	22.500	1.000
2.000	19.550	2.000	19.550	1.000
2.500	16.090	2.500	16.090	1.000
3.000	12.100	3.000	13.235	1.000
3.000	14.370	3.000	13.235	1.000
4.000	11.000	4.000	11.000	1.000
5.000	9.000	5.000	9.000	1.000
6.500	7.800	6.500	8.500	1.000
8.000	8.420	8.000	9.000	1.000
10.000	10.200	10.000	10.955	1.000
10.000	11.710	10.000	10.955	1.000
12.500	14.670	12.500	14.670	1.000
16.000	19.450	16.000	19.450	1.000
20.000	25.000	20.000	25.000	1.000
25.000	33.000	25.000	33.000	1.000
30.000	40.340	30.000	39.805	1.000
30.000	39.270	30.000	39.805	1.000

40.000	54.670	40.000	53.890	1.000
40.000	53.110	40.000	53.890	1.000
50.000	64.900	50.000	64.900	1.000
65.000	75.500	65.000	75.500	1.000
80.000	88.060	80.000	88.060	1.000
100.000	102.300	100.000	102.300	1.000

Garmedo Sirba-6

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	63.250	1.000	63.250	1.000
1.250	59.570	1.250	59.570	1.000
1.600	54.730	1.600	54.730	1.000
2.000	51.760	2.000	51.760	1.000
2.500	54.390	2.500	54.390	1.000
3.000	60.040	3.000	55.145	1.000
3.000	50.250	3.000	55.145	1.000
4.000	68.630	4.000	68.630	1.000
5.000	68.630	5.000	68.630	1.000
6.500	86.050	6.500	86.050	1.000
8.000	102.990	8.000	102.990	1.000
10.000	122.440	10.000	112.570	1.000
10.000	102.700	10.000	112.570	1.000
12.500	113.260	12.500	113.260	1.000
16.000	121.190	16.000	121.190	1.000
20.000	127.280	20.000	127.280	1.000
25.000	120.230	25.000	120.230	1.000
30.000	116.520	30.000	111.985	1.000
30.000	107.450	30.000	111.985	1.000
40.000	109.660	40.000	105.610	1.000
40.000	101.560	40.000	105.610	1.000
50.000	106.500	50.000	106.500	1.000
65.000	118.600	65.000	118.600	1.000
80.000	138.640	80.000	138.640	1.000
100.000	175.060	100.000	175.060	1.000

Schlumberger Array

Garmedo Sirba-7

Raw Dist	Raw Res.	Smoothed dist	Smoothed Res.	variances
1.000	81.330	1.000	81.330	1.000
1.250	78.560	1.250	78.560	1.000
1.600	75.760	1.600	75.760	1.000
2.000	81.410	2.000	81.410	1.000
2.500	85.650	2.500	85.650	1.000

3.000	90.830	3.000	82.290	1.000
3.000	73.750	3.000	82.290	1.000
4.000	81.340	4.000	81.340	1.000
5.000	85.000	5.000	85.000	1.000
6.500	97.430	6.500	97.430	1.000
8.000	99.740	8.000	99.740	1.000
10.000	105.030	10.000	100.315	1.000
10.000	95.600	10.000	100.315	1.000
12.500	106.270	12.500	106.270	1.000
16.000	121.440	16.000	121.440	1.000
20.000	130.510	20.000	130.510	1.000
25.000	124.725	25.000	124.725	1.000
30.000	120.400	30.000	120.895	1.000
30.000	121.390	30.000	120.895	1.000
40.000	130.610	40.000	130.905	1.000
40.000	131.200	40.000	130.905	1.000
50.000	143.900	50.000	143.900	1.000
65.000	154.370	65.000	154.370	1.000
80.000	157.890	80.000	157.890	1.000
100.000	169.020	100.000	169.020	1.000

Annex 4: Well Accomplishment Report

COOPI
Drought consequence Alleviation Project in Borena zone

Technical Report of Rural Water Wells construction in Liben Woreda

August, 2003

Negele Borena

Table of contents

Preface

Usually technical report of the well construction work consist the depth of the hole, packing ways, casing arrangements, pumping tests and lithological logs. Additionally it may include the excavation work history and well head construction work.

This report also done in away to fulfill the above mentioned points, and the location map of each sites are attached with. The activities on each site are discussed separately, because it thought to give the reporter enough chance to show for readers about un usual circumstances happening in some of the sites. Off course, it creates repetition in the report.

Additionally some sketches and location maps are also attached since it can give the readers the better picture regarding the location of the sites and/ the final appearance of the sites. Hydro-geological soft ware Packages such as Aquifer Test and GWW programs are used in the report for better presentation and for the analysis of pumping test data.

Finally I would like to suggest my readers not to take the described aquifer parameter values as very liable result from pumping test analysis, because describing the aquifer parameters using large size pumping well is to complicated; moreover, it depends on the view of the person conducting the test. But the raw data can be used by those who want to interpret the data by them selves.

Thank you,

Getachew Alefe
COOPI-Negele Office
August, 2003

I- Back Ground

Gujii zone is one of the administrative zones of Oromia national regional state. The zone consists of eight woredas and Liben woreda is one them. Liben woreda located in the south part of the zone and it bordered by: Somali national Regional state by south, Borena zone and Shakiso-Odo woreda by west, Bale zone by east and Wadera woreda by north. The capital of the woreda is Negele town and the town far 595km from Addiss Abeba towards south.

Liben woreda is one the areas where recurrent drought appear and it's the place where the problem related shortage of potable is very high. Water plays the vital role in the livelihoods of the woredas' community since they practice Agro-pastoral way of life.

COOPI has been working on different development sectors in the woreda since several years ago to alleviate the communities' major problems. Water sector has been one of the main sectors of intervention for COOPI, and still the organization is actively participating in the alleviation of the stress imposed on the community as result shortage of potable water sources.

Recently the organization formulated a project under head title of 'Drought Consequences Alleviation in Borena Zone', which targeted on the alleviation of the problems that could happen after the drought period of 2001/2002.

The main frame work of the project comprises the construction of ten hand-dug wells equipped with hand-pumps and other two hand-dug wells equipped with solar power driven submersible pumps. The water wells are located in the places either where the availability of potable water sources are not the existing at all or in the places located far from the existing water sources.

Identification of the areas, where the scarcity of water is high and setting project proposal had been done jointly by COOPI and BZWMERDD. Following the feasibility study, COOPI preceded on the implementation of the project by the fund secured from USAID-OFDA.

SOLAR PUMP INSTALLED WELL SITES

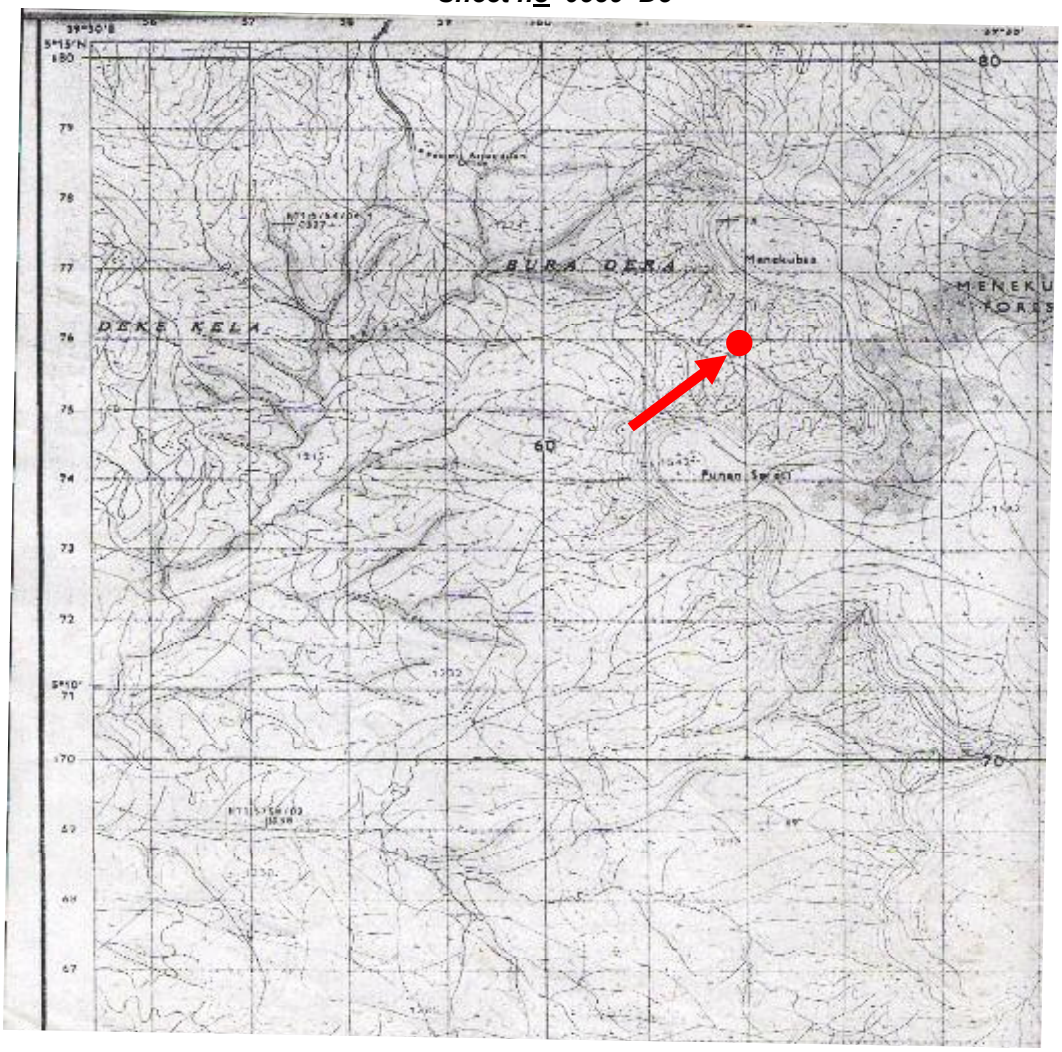
1- Buradhera

1-1 Location

The site locate by south Negele, and it accessible by dry whether road. The site fars 22km from Negele, via Mersa Village. In UTM geographic system the site appear at:

Zone 37N
North 561253m
East 576286m

Location Map of Bura Dhera
Adapted from 1:50,000 topographic map
Of Siminto
Sheet no 0539 D3



1-2 Well excavation work

Well excavation work started in June, 2002 and completed on July18, 2002. The diameter of the well was 2.2m, and the final depth of the well is 15m. Water stroke at the depth of 9.5m and the static water level inside the well is 8.78m below ground level. The main aquifer of the well is fractured shiest, and the excavation work completed with no major trouble.

1-3 casing

Blind as well as slotted concrete ring casings were lowered in to the well according to the following order from the ground level:

Blind 0 up to 7m
Screen (slotted rings) 7m up to end depth i.e. 15m.

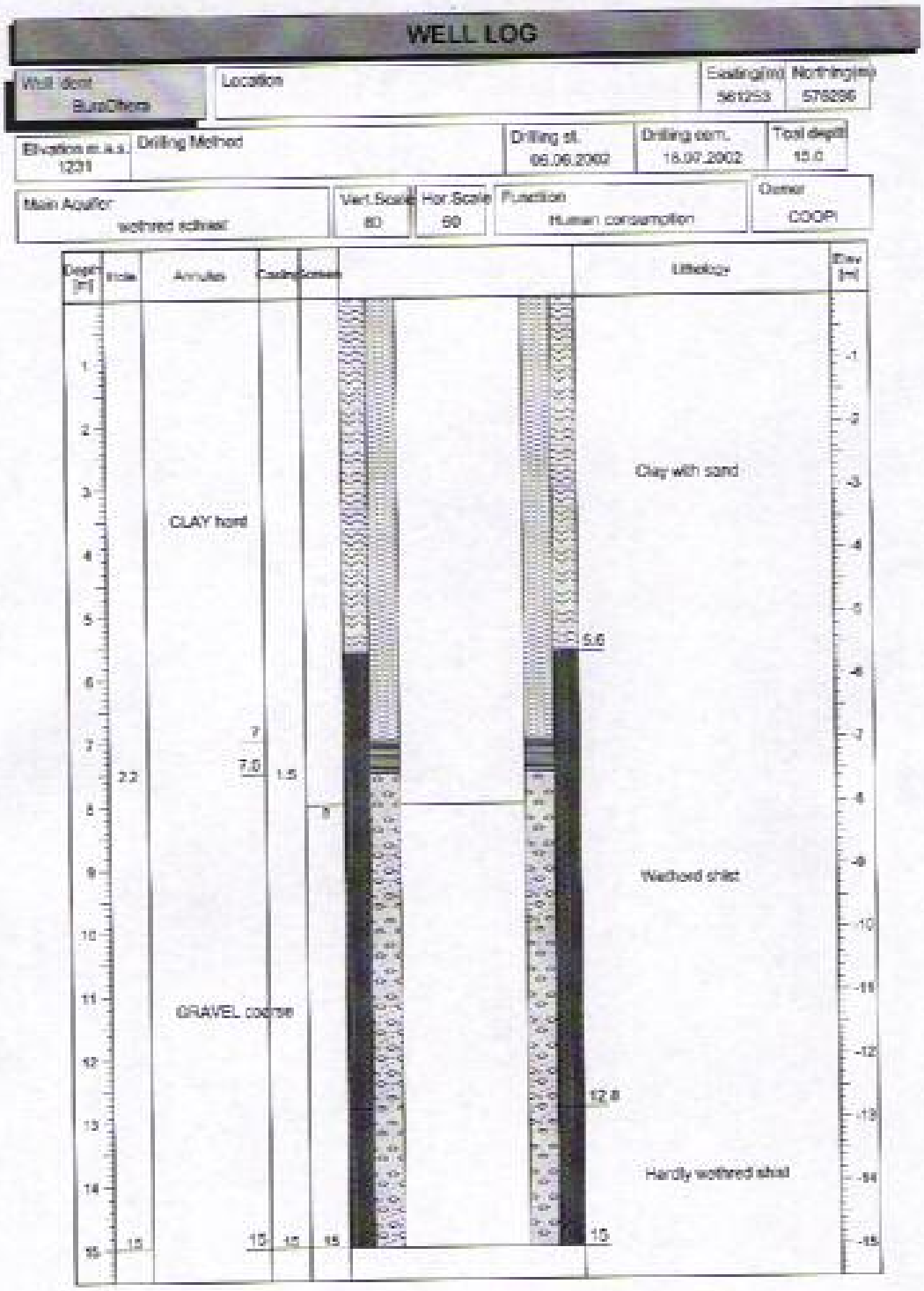
The ring is further rise 0.60m above ground level to prevent flooding and to permit the well head structure. The diameter of the rings is same, and it is 1.5m in the internal part and 1.7m in the outer part.

1-4 Packing

The well annular space packed by selected river gravel from the depth of 7.5m up to the bottom of the well to facilitate the in flow of water into the well and to server as filtering media. The rest part of the well was packed by clay with in order to prevent the percolation of water in to the well. The clay pack and the gravel pack layers separated by O.5m thick cement pack.

1-5 Well log

Samples were continuously observed in order to identify the lithological layering and the samples are used to set the well log. The well lithological log and the well casing as well as packing design are shown on the following chart.


WELL LOG
Well Ident
BurqOhora
Location
Easting(m)
561253
Northing(m)
5758296
Elvation m.a.s.l.
1231
Drilling Method
Drilling st.
06.06.2002
Drilling com.
18.07.2002
Tool depth
15.0
Main Aquifer
wathred rchkest
Vert.Scale
80
Hor.Scale
50
Function
Human consumption
Owner
COOPI
Depth [m]
Index
Annulus
Coding
Contact
Litholgy
Elev [m]
CLAY hard
Clay with sand
Wathred shist
GRAVEL coarse
Hardly wathred shist
5.6
7
7.0
1.5
2.2
12.8
15
15
15
15

1-6 Pumping test

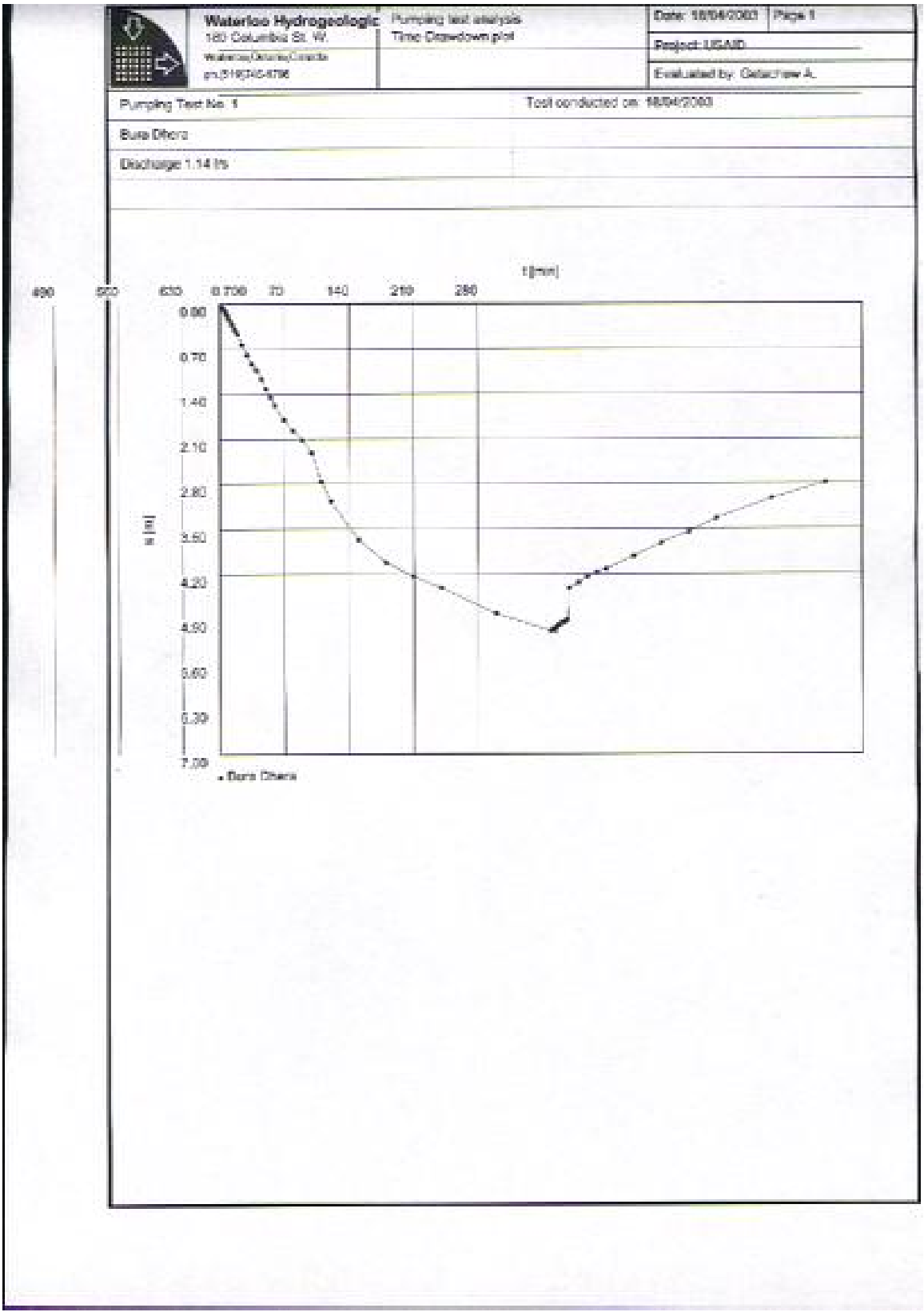
Constant discharge test was adapted for the well test. The test carried out for total of 11 hours including the recovery test, and the data obtained from the test used in Cooper and Jacob equations to calculate transimisivity. The general information regarding the test shown below and the result obtained from the analysis are presented in the following pages.

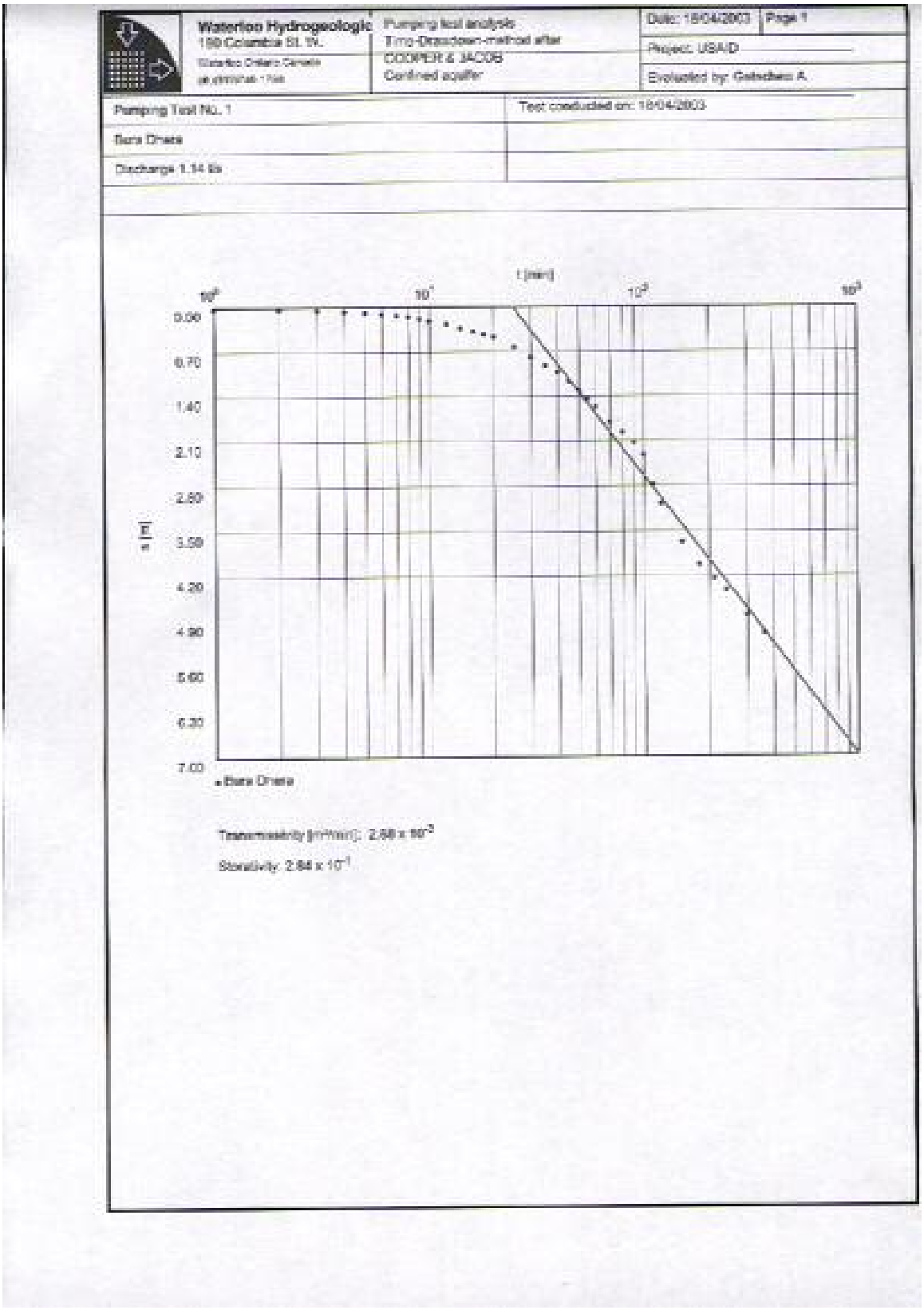
Date of test 18/04/2003	Constant Discharge Test
Location: Zone Borena	SWL 9.38m
District Liben	Ref.Point 60cm A.G.L
Kebele Bura Dhera	Q(lit/sec) 1.14m

1-7 Water quality

Water sample had taken in the end period of the pumping test. The water sample physically looks colorless and odorless. The sample also tested for some drinking water quality parameters and the result obtained from the test listed below.

Conductivity	3520 µs/cm
Temperature	28.2^0c
Total Hardness	569.6ppm, very hard
Chloride Cl-	350mg/lit
Ph	7.5
Ammonium	nill
Nitrite	1mg/lit
Sulfate	<200ppm


Waterloo Hydrogeologic
160 Columbia St. W.
Pumping test analysis
Time Drawdown plot
Date: 18/04/2003
Page 1
Project: USAID
Evaluated by: Getachew A.
Pumping Test No: 1
Test conducted on: 18/04/2003
Bura Dhera
Discharge: 1.14 l/s
t [min]
500
600
0.700
70
140
210
280
0.00
0.70
1.40
2.10
2.80
3.50
4.20
4.90
5.60
6.30
7.00
s [m]
Bura Dhera


Waterloo Hydrogeologic
Pumping test analysis
Theis-Drawdown-method after
COOPER & JACOB
Confined aquifer
Date: 18/04/2003
Page 1
Project: USAID
Evaluated by: Getechew A.
Pumping Test NO.: 1
Test conducted on: 18/04/2003
Bore Dhera
Discharge 1.14 l/s
t [min]
0.00
0.70
1.40
2.10
2.80
3.50
4.20
4.90
5.60
6.30
7.00
Bore Dhera
Storativity: 2.84 x 10

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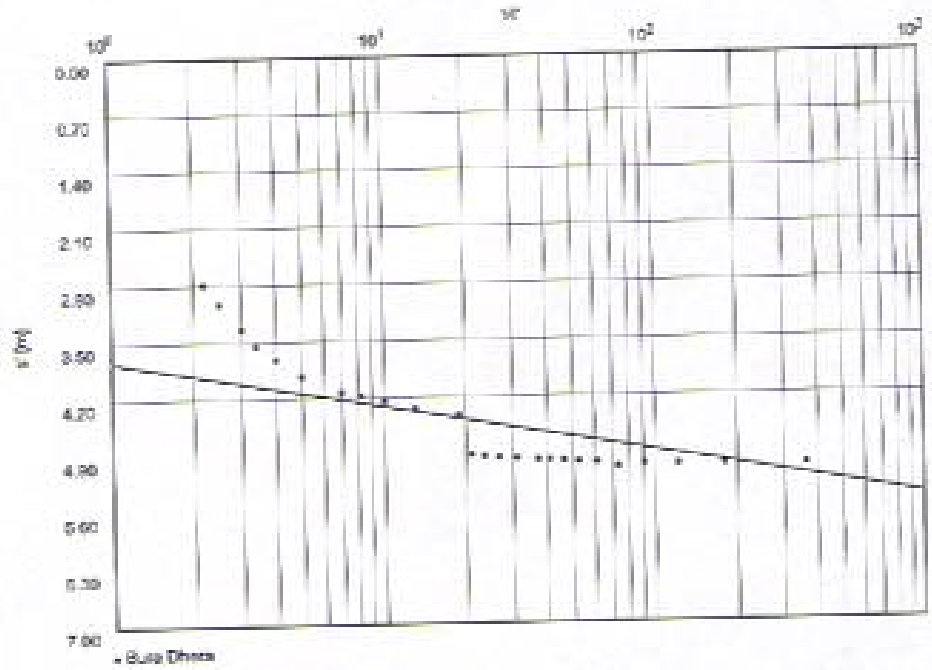
Pumping test analysis
Recovery method after
THEIS & JACOB
Confined aquifer

Date: 18/04/2003 | Page 1
Project: USAID
Evaluated by: Gellechew A.

Pumping Well No. 1
Test conducted on: 18/04/2003
Bore Dhara
Discharge 1.94 l/s
Pumping test duration: 360.00 min



Transmissibility [m²/min]: 2.18 x 10⁻²

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Pumping test analysis
Time-Drawdown plot

Date: 18/04/2003 | Page 2
Project: USAID
Evaluated by: Getachew A.

Pumping Test No. 1
Test conducted on: 18/04/2003
Buna Dhera
Buna Dhera
Discharge 1.14 l/s
Distance from the pumping well 0.750 m
Static water level: 9.380 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]
1	1.00	9.410	0.030
2	2.00	9.420	0.040
3	3.00	9.430	0.050
4	4.00	9.450	0.070
5	5.00	9.470	0.090
6	6.00	9.490	0.110
7	7.00	9.510	0.130
8	8.00	9.530	0.150
9	9.00	9.550	0.170
10	10.00	9.600	0.220
11	12.00	9.650	0.270
12	14.00	9.710	0.330
13	16.00	9.770	0.390
14	18.00	9.810	0.430
15	20.00	9.850	0.470
16	25.00	10.010	0.630
17	30.00	10.170	0.790
18	35.00	10.310	0.930
19	40.00	10.410	1.030
20	45.00	10.609	1.170
21	50.00	10.709	1.320
22	60.00	10.830	1.450
23	60.00	10.980	1.580
24	70.00	11.190	1.810
25	80.00	11.350	1.970
26	90.00	11.500	2.120
27	100.00	11.700	2.320
28	110.00	12.150	2.770
29	120.00	12.450	3.070
30	150.00	13.050	3.670
31	180.00	13.400	4.020
32	210.00	13.620	4.240
33	240.00	13.800	4.420
34	300.00	14.200	4.820
35	330.00	14.470	5.090
36	351.00	14.460	5.080
37	352.00	14.450	5.070
38	353.00	14.440	5.060
39	354.00	14.430	5.050
40	355.00	14.470	5.090
41	356.00	14.410	5.030
42	357.00	14.400	5.020
43	358.00	14.390	5.010
44	359.00	14.380	5.000
45	370.00	14.370	4.990
46	372.00	14.350	4.970
47	374.00	14.340	4.960
48	376.00	14.320	4.940
49	378.00	14.300	4.920
50	380.00	13.810	4.430

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Pumping test analysis
Time-Drawdown plot

Date: 18/04/2003 | Page 3
Project: USAID
Evaluated by: Gollachew A.

Pumping Test No. 1 | Test conducted on 18/04/2003
Bure Dhera | Bure Dhera
Discharge 1.14 l/s | Distance from the pumping well 0.750 m
Static water level 9.380 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]
51	390.00	13.720	4.340
52	400.00	13.630	4.250
53	410.00	13.560	4.180
54	420.00	13.510	4.130
55	430.00	13.310	3.930
56	460.00	13.100	3.720
57	510.00	12.980	3.650
58	540.00	12.720	3.340
59	600.00	12.410	3.030
60	600.00	12.170	2.790

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Pumping test analysis
Recovery method after
THEIS & JACOB
Confined aquifer

Date: 18/04/2003 | Page 2
Project: USAID
Evaluated by: Gotnchea A.

Pumping Test No.: 1
Test conducted on: 18/04/2003
Bara Dhera
Bura Dhera
Discharge: 1.14 lps
Distance from the pumping well: 750 m
Static water level: 9.380 m below datum
Pumping test duration: 360.00 min

	Time from end of pumping [min]	Water level [m]	Residual drawdown [m]
1	1.00	14.460	5.080
2	2.00	14.450	5.070
3	3.00	14.440	5.060
4	4.00	14.430	5.050
5	5.00	14.470	5.090
6	6.00	14.470	5.090
7	7.00	14.460	5.080
8	8.00	14.390	5.010
9	9.00	14.380	5.000
10	10.00	14.370	4.990
11	12.00	14.360	4.980
12	14.00	14.340	4.960
13	16.00	14.320	4.940
14	18.00	14.300	4.920
15	20.00	13.810	4.430
16	30.00	13.720	4.340
17	40.00	13.630	4.250
18	50.00	13.560	4.180
19	60.00	13.510	4.130
20	90.00	13.310	3.930
21	120.00	13.100	3.720
22	150.00	12.980	3.600
23	180.00	12.720	3.340
24	240.00	12.410	3.030
25	300.00	12.170	2.790

1.8 well head

The head constructed on the well is the usual COOPI standard well head i.e. 4m*4m with concrete slab on top. First the structure rise from the ground to sufficient height (average=0.60m) by masonry and on top covered by reinforced concrete slab with manhole and inlet hole for both the submersible and hand pump.

1-9 Pumps

Solar energy driven submersible pump and hand pump are installed on the well. The submersible pump uses to lift water in to the tanker during sunny time, while the hand pump installed to be used when the solar driven pump is not functional. The brand of the hand-pump is ***Indian Mar*** II, and PVC pipe of 2" size used as suction pipe.

The Suction pipe of the submersible pump is PET pipe of 2" size, and the pump positioned at 14m below ground level.

The characteristic of the Submersible pump is:

- Brand - Calpeda
- Model – 4 SD 5/5E
- Made in – Italy
- HP – 0.5 / 0.37 Kw
- RPM – 2900/min
- Discharge- *Maximum 4.8 m^3/h at 13m head*
  Minimum 0.6 m^3/h at 30m head

1-10 Other structures

i. Tanker- 10m^3 ***FiberGlass*** tanker was set to reserve water. The tanker rise to the height of 6m above ground level, and it set dawn on iron bar tanker supporter. The assembling of the tanker supporter was carried out at the site level, and erected after. The legs of the supporter lay on pre constructed concrete foundation that constructed to increase the bearing capacity of the soil.

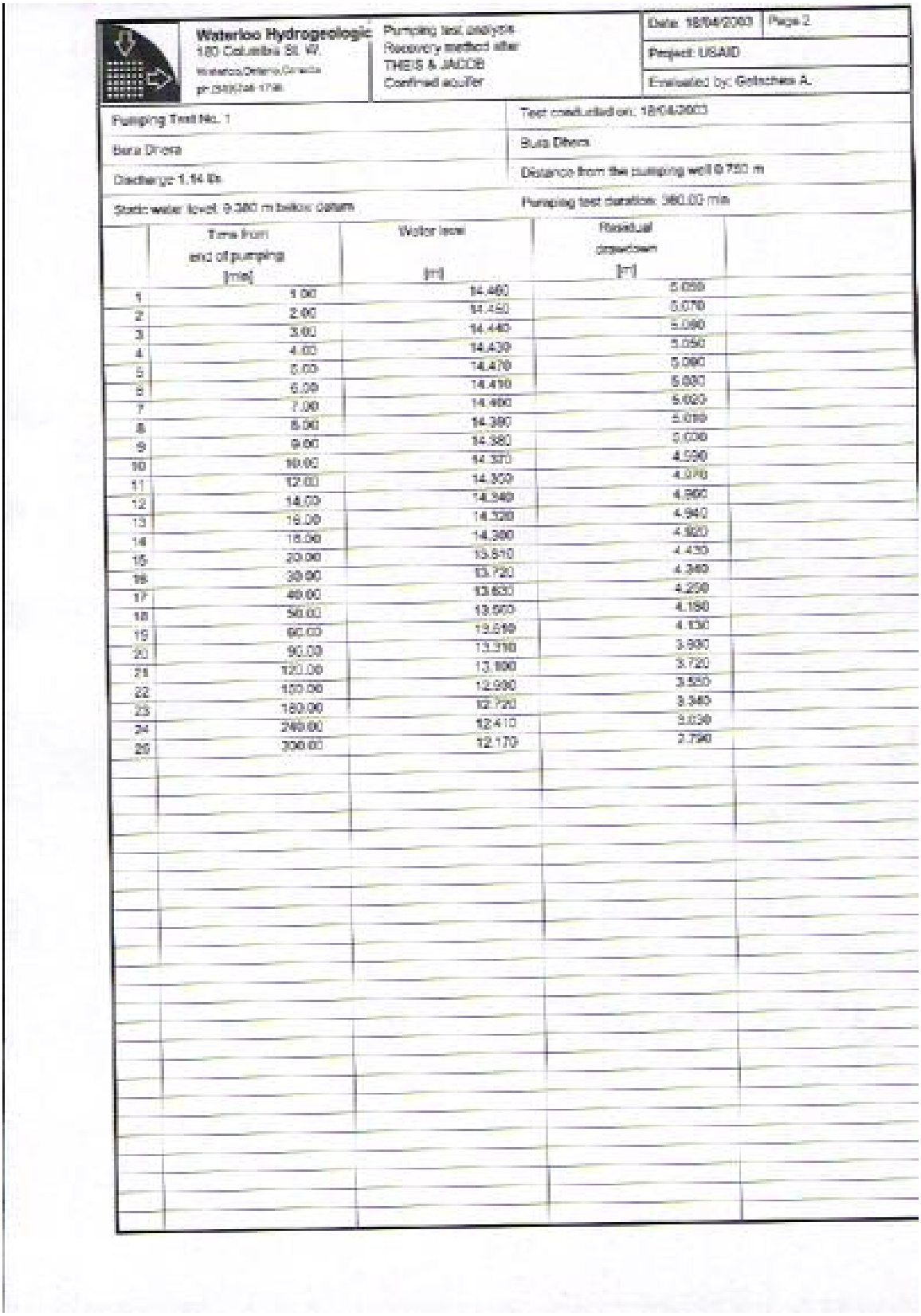
ii. Control House- the house constructed to put the solar drive control switch board. The house constructed by stone wall and sheet iron roof. The designee of the house is annexed.

iii. Public fountain- One public fountain with four valves is constructed. The fountain was constructed in away that peoples can fetch water with out any trouble. The design of the public fountain is also annexed.

iv. Solar Panel- the solar panel use to receive the solar radiation and to convert it in to electrical energy in order to drive the submersible pump. The solar panel support was fixed on masonry foundation and it set in a way that it can receive the sun radiation through out the day time.

v. Pipe lay- The pressure line from the pump to the tanker was set by PET and PVC pipes of 2'' size. For the distribution line that is from the tanker to the public fountain, ½" PET pipes are used. The line are fitted with the necessary fittings, and water counters also fixed on the out let from the tanker and on pressure line from the pump.

vi. Fence – finally the site fenced by barbed wire with supporting poles of angle iron. The fenced compound has two doors made of tubolare.



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Pumping test analysis
Recovery method after
THEIS & JACOB
Confined aquifer

Date: 18/04/2003 | Page 2

Project: USAID

Evaluated by: Gebrehiwot A.

Pumping Test No.: 1

Test conducted on: 18/04/2003

Bore Drora

Bura Dhera

Discharge: 1.14 lps

Distance from the pumping well: 750 m

Static water level: 9.380 m below datum

Pumping test duration: 360.00 min

	Time from end of pumping [min]	Water level [m]	Residual drawdown [m]
1	1.00	14.460	5.080
2	2.00	14.450	5.070
3	3.00	14.440	5.060
4	4.00	14.430	5.050
5	5.00	14.470	5.090
6	6.00	14.410	5.030
7	7.00	14.400	5.020
8	8.00	14.390	5.010
9	9.00	14.380	5.000
10	10.00	14.370	4.990
11	12.00	14.360	4.980
12	14.00	14.340	4.960
13	16.00	14.320	4.940
14	18.00	14.300	4.920
15	20.00	13.810	4.430
16	30.00	13.720	4.340
17	40.00	13.630	4.250
18	50.00	13.550	4.170
19	60.00	13.510	4.130
20	90.00	13.310	3.930
21	120.00	13.100	3.720
22	150.00	12.930	3.550
23	180.00	12.720	3.340
24	240.00	12.410	3.030
25	300.00	12.170	2.790

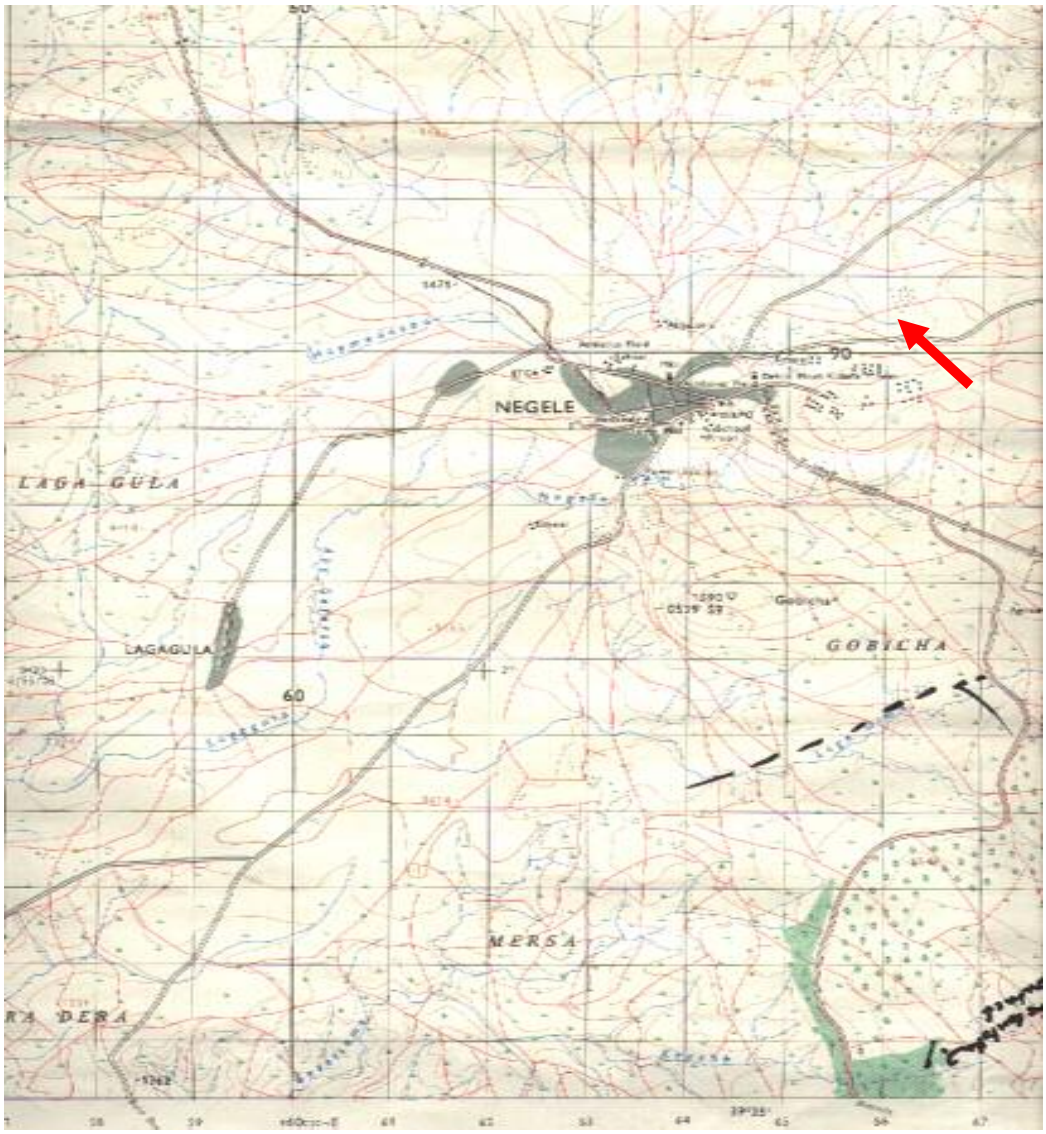
2- Wefe

2-1Location Of the site

Wefe situated by Northeast of Negele, behind the military base of Negele. The place fars 4km from the center of the town, and In UTM geographic coordinate system, the specific site of water intervention appear at:

Zone	37N
East	566220m
North	590533m

Map-1 Location map of Wefe area
Adapted from 1:50,000 topographic map
Of Negele Borena sheet
Sheet 0539D1



2-2 Well excavation work

Well excavation work started on April 28, 2003. The excavation was progressed up to 8m with out any trouble, but after the layer become very strong to dig further deep. Water stroked at the depth of 4.10m and the amount of water increased with increasing of depth up to 8m.

The excavation work stopped temporarily at the depth of 8.65m to check the productivity of the well using submersible pumps. However; the result from the test reveled that the productivity of the well is not as much as the yield required for solar driven submersible pump. So that, additional lateral as well as vertical excavation work carried out to increase the productivity of the well.

The vertical excavation work includes:

- Excavation further deeper in to the main well up to 11m. Although the layers are not water bearing, it possibly increases the reserving capacity of the well.
- Excavation of additional new well 15.5m away from the previous and connecting it with pipe lay inside the trench. It thought to increase both the reserving capacity as well as productivity since it significantly increase the surface area of the aquifer on the side of the wells.

The depth of the second well is 7m and the initial diameter of the well was 2.5m. The well size reduced to 2.2m below 3.8m. Water stroked at 3.5m depth and the amount of water increased significantly with increasing depth.

The lateral excavation work includes excavation of 15.3m long trench up average depth of 7.25m in telescopic fashion. The width of the trench was 1.5m meter up to the depth 3m and the width reduced to 1m below 3m.The trench was excavated in away that to tilt little towards the first well so as to facilitate the flow of water from the other well as well as from the trench itself. As result the depth of the trench is 7m at the second well and it is 7.5 at the first well.

Fig- The view of the trench from the mine well to the second well.

In order to create open connection between the two wells, GI pipe of 4" laid in side the trench. The pipe lines are two and the put inside the trench in parallel way. The length of each line is 16.5m, and the pipes are perforated from the top in order to increase the in flow of water to the main well through lines from the trench itself.

2-3Casing

Blind as well as perforated concrete rings were lowered inside both two wells. The diameter of each Casing is 1.5m in the inner part and 1.7m in the outer part. The arrangement of the casing in each well is as follows from the ground level:

No	Well	Blind casing		Perforated(screens)	
		From (m)	To (m)	From (m)	To(m)
1	Main well	0	5	5	11
2	Second well	0	4	4	7

Note: in both wells the casing rise 0.8m above ground level for the construction of well head.

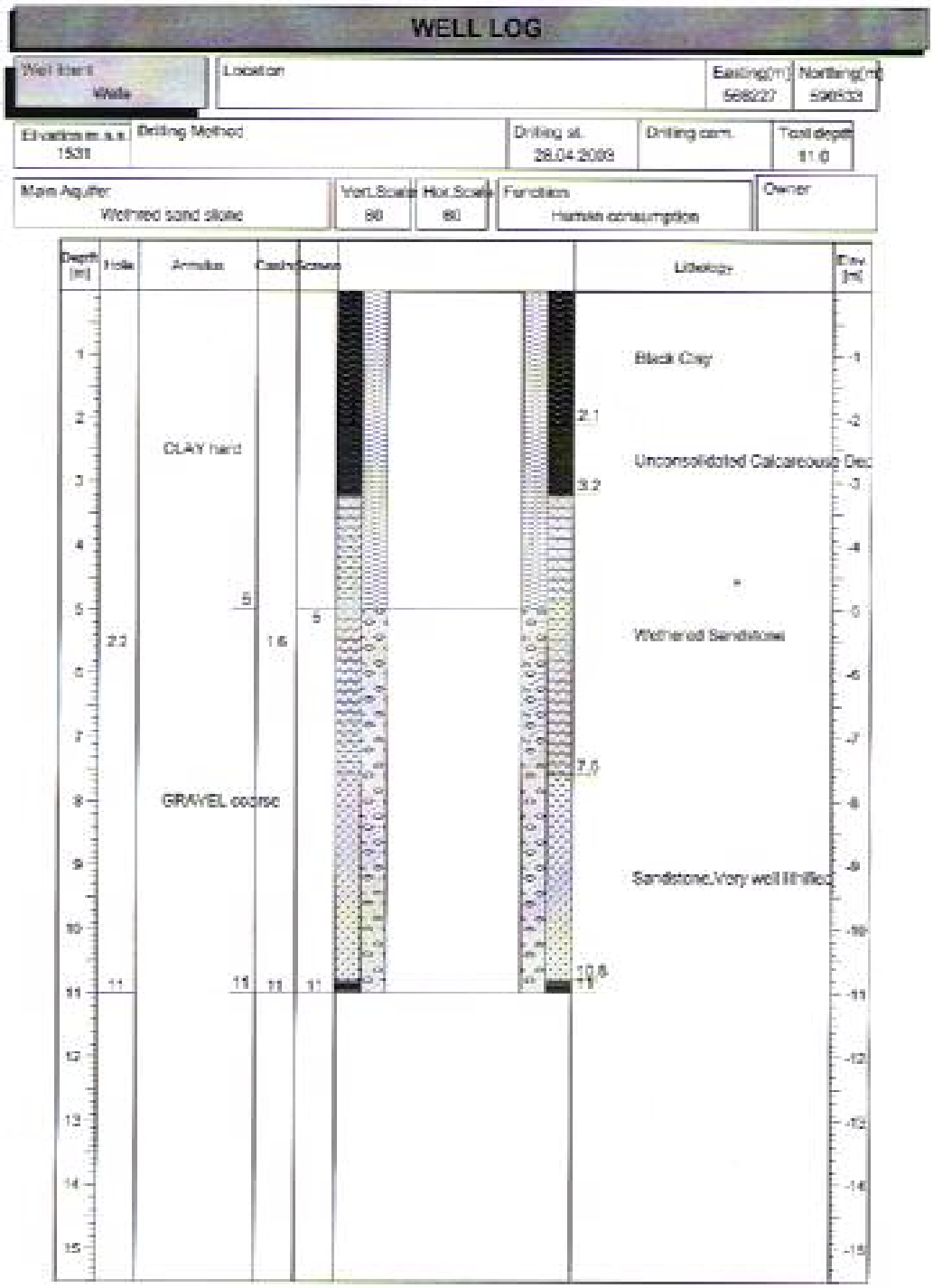
2-4 Packing

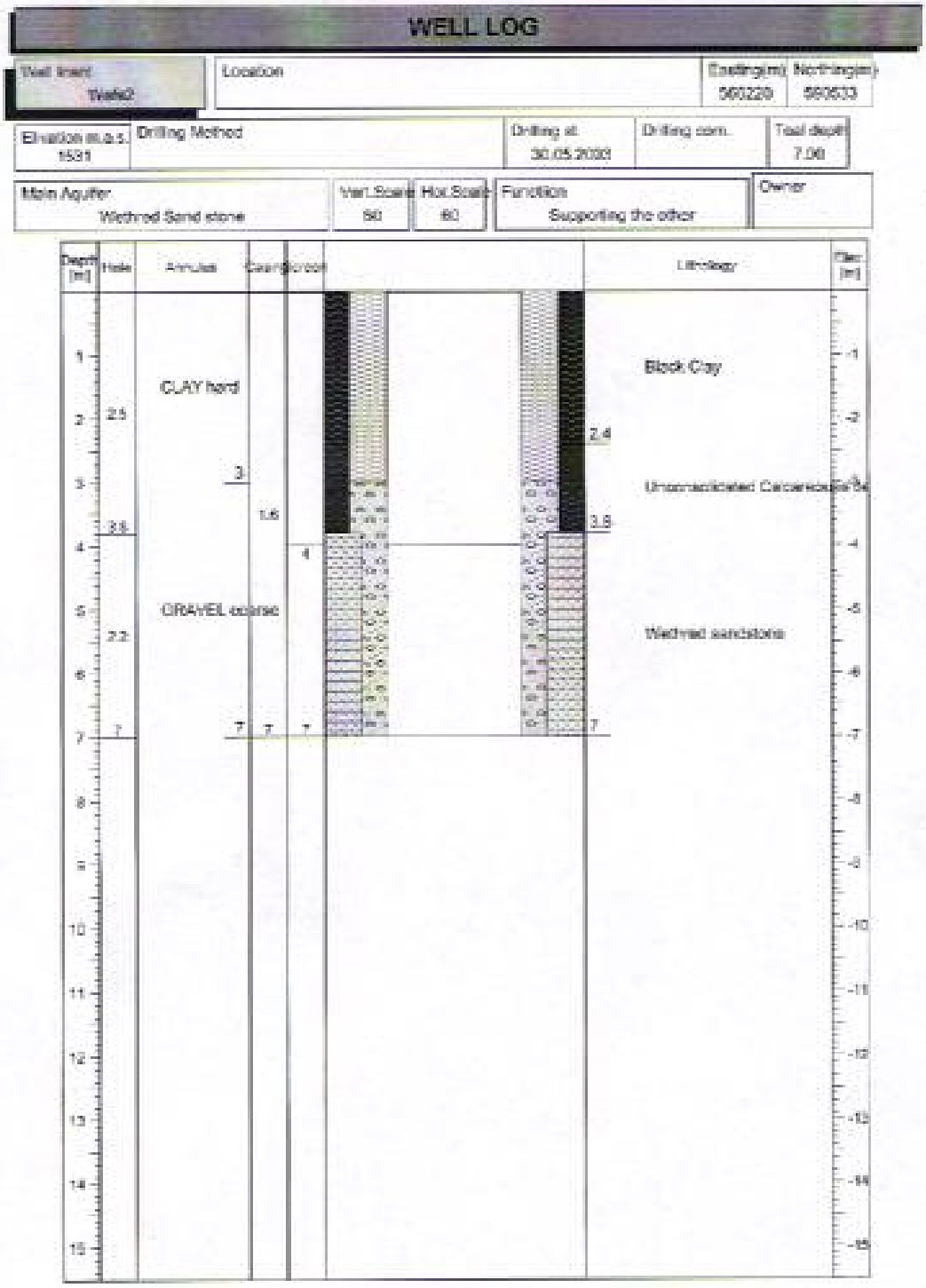
In order to facilitate the in flow of water in to the wells and to create filtering media, selected river gravel poured in the well annular space (between the outer rim of the casing and the internal wall of the well) as well in the trench.

In the main well the gravel filled up to the depth of 5m while in the second the gravel filled up to 3m depth. The trench, like the wells, filled by gravel to depth of 5m and on the top of grave crushed stones was poured. Clay is used to pack up to the level of ground from the layer of gravel pack.

2-5 Well Log

Samples were observed frequently in order to understand the vertical variation of the layers.
The samples used to differentiate water bearing layer from the other layers, and also use to design the arrangement of the casing. The lithological logs of the two wells with the casing arrangement and packing are shown in the following two graphs, respectively.


WELL LOG
Well Ident.
Wells
Location
Easting(m)
568227
Northing(m)
598533
Elevation m. a.s.l.
1531
Drilling Method
Drilling st.
28.04.2009
Drilling com.
Total depth
81.0
Main Aquifer
Weltered sand stone
Ver.Scale
80
Hor.Scale
80
Function
Human consumption
Owner
Depth [m]
Hole
Annulus
Casing
Screen
Lithology
Elev [m]
Black Clay
CLAY hard
Unconsolidated Calcareous Dep
Weltered Sandstone
GRAVEL coarse
Sandstone,Very well lithified
2.1
3.2
7.0
10.8
5
11
22
16


WELL LOG
Well Insert
Well2
Location
Easting(m)
560229
Northing(m)
560633
Elevation m.a.s.l.
1531
Drilling Method
Drilling st.
30.05.2020
Drilling com.
Total depth
7.00
Main Aquifer
Wetmed Sand stone
Ver.Scale
50
Hor.Scale
50
Function
Supporting the other
Owner
Depth [m]
Hole
Annulus
Casing/screen
Lithology
Elev. [m]
CLAY hard
GRAVEL coarse
Black Clay
Unconsolidated Calcareous Sa
Wetmed sandstone
2.5
3
3.5
2.2
7
1.6
4
2.4
3.5
7

2-6 well head

The well head constructed on the main is the usual COOPI standard well head i.e. 4m*4m with concrete slab on top. First the structure rise from the ground to sufficient height (average=0.60m) by masonry and on top covered by reinforced concrete slab with manhole and inlet hole for both the submersible and hand pump.

Fig-2 the second well head construction on progress

The general structure of the well head is the same for the second well but the dimension of the well head on the second well reduced to 3m*3m with one manhole only. *The standard well designee of COOPI is annexed.*

2-7Pumps

Solar energy driven submersible pump and hand pump are installed in the main well. The submersible pump uses to lift water in to the tanker during sunny time, while the hand pump installed to be used when the solar driven pump is not functional.

The Suction pipe of the submersible pump is PET pipe of two 2" size, and the pump positioned at 10.6m below ground level. The brand of the hand pump is ***Indian Mar*** II, PVC pipe of 2" size used as suction pipe.

The characteristic of the Submersible pump is:

- Brand - Calpeda
- Model – 4 SD 5/5E
- Made in – Italy
- HP – 0.5 / 0.37 Kw
- RPM – 2900/min
- Discharge- *Maximum 4.8 m^3/h at 13m head*
  Minimum 0.6 m^3/h at 30m head

2-8 Other structures

vii. Tanker- 10m^3 ***FiberGlass*** tanker was set to reserve water. The tanker rise to the height of 6m above ground level, and it set dawn on iron bar tanker supporter. The assembling of the tanker supporter was carried out at the site level, and erected after. The legs of the supporter lay on pre constructed concrete foundation that constructed to increase the bearing capacity of the soil.

viii. Control House- the house constructed to put the solar drive control switch board. The house constructed by stone wall and sheet iron roof. The designee of the house also annexed.

ix. Public fountain- One public fountain with four valves is also constructed. The fountain was constructed in away that peoples can fetch water with out any trouble. The design of the public fountain is also annexed.

x. Solar Panel- the solar panel use to receive the radiation and to convert it in to electrical energy in order to drive the submersible pump. The solar panel support was fixed on masonry foundation and it set in a way that it can receive the radiation through out the day time.

xi. Pipe lay- The pressure line from the pump to the tanker was set by PET and PVC pipes of 2'' size. For the distribution line that is from the tanker to the public fountain, ½" PET pipes are used. The line also fitted with the necessary fittings and water counters are also fixed on the out lets from the tanker and on pressure line.

xii. Fence – finally the site fenced by barbed wire with supporting poles of angle iron. The fence has two doors made of tubulare.

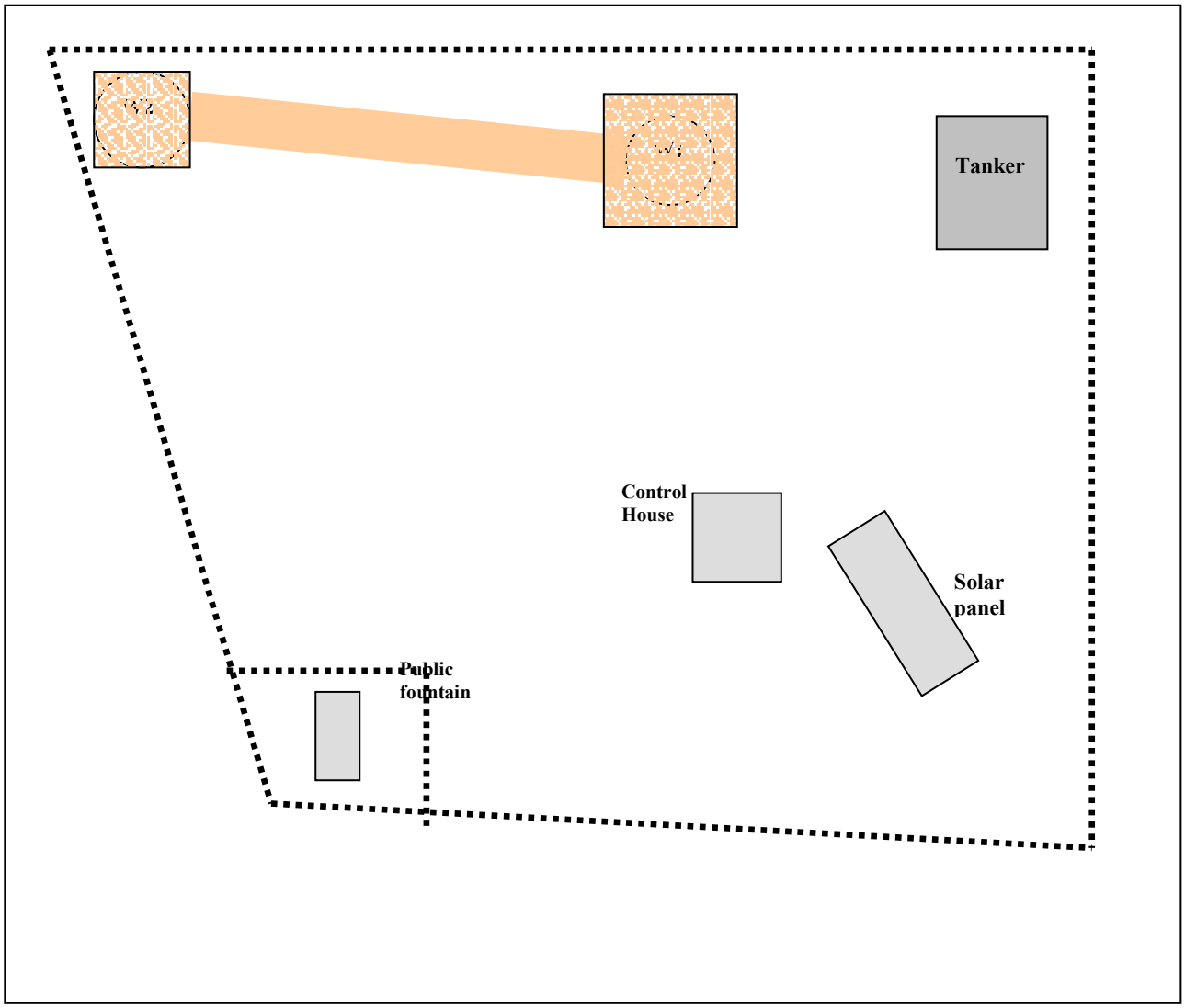


Fig- The site plane sketch, not on true scale

2-9 Pumping test

Constant discharge test was adapted for the well test. The test carried out for total of 7 hours and the result obtained from the test used in Cooper and Jacob equations to calculate transimisivity. The general information regarding the test and the result obtained are presented below.

Date of test 29/07/2003	Constant Discharge Test
Location: Zone Borena	SWL 4.1m
District Liben	Ref.Point 70cm A.G.L
Kebele Wefe	Q(lit/sec) 7.15

2-10 Water quality

Water sample had taken in the end period of the pumping test. The water sample physically looks colorless and odorless. The sample also tested for some drinking water quality parameters and the result obtained from the test listed below.

Conductivity	1358 µs/cm
Temperature	23.8^0c
Total Hardness	Hard
Chloride Cl-	125mg/lit
Ph	7.5
Ammonium	1mg/lit
Nitrite	-
Nitrate	-
Sulfate	<200ppm

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Pumping test analysis
Time-Drawdown plot
with discharge

Date: 11.08.2003 | Page 1

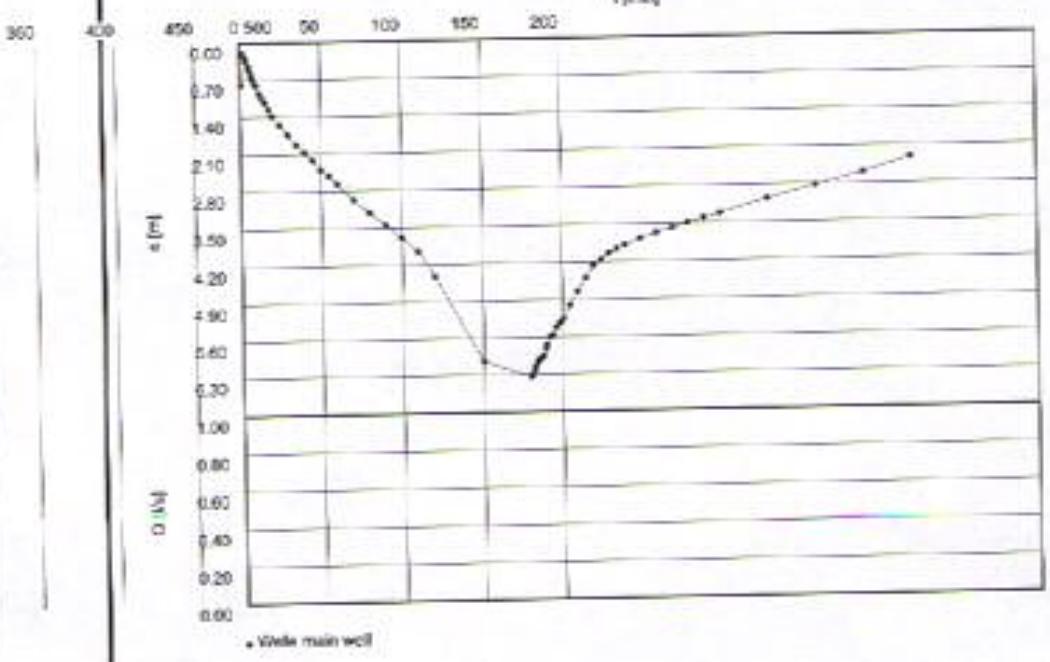
Project: USAID-OFDA

Evaluated by: Getachew Akele

Pumping Test No. 2

Test conducted on: 29.7.2003

Wells

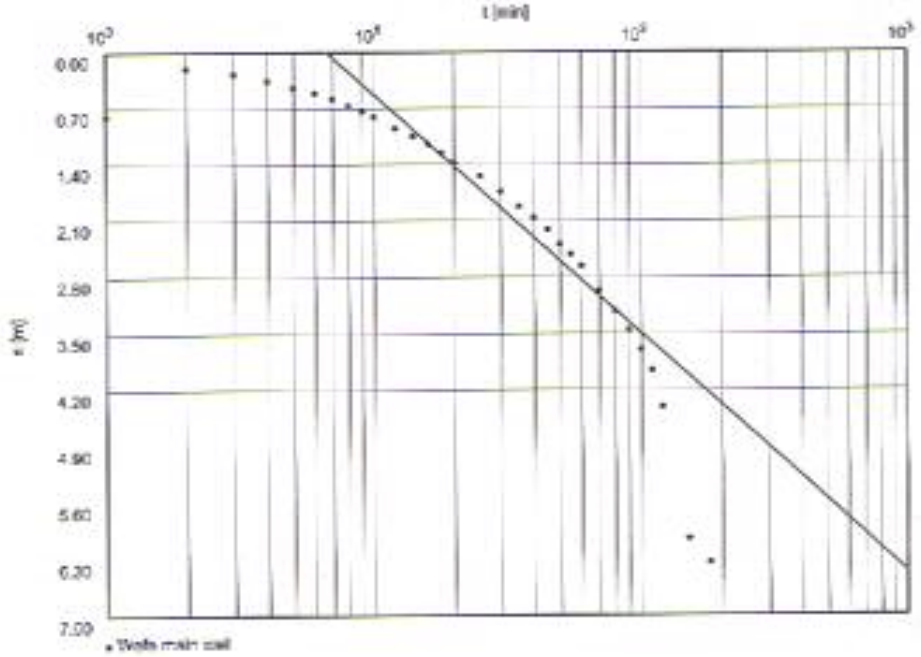


Waterloo Hydrogeologic 180 Columbia St. W.	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 11.08.2003	Page 1
		Project: USAID-OFDA	
		Evaluated by: Getachew Alelle	

Pumping Test No. 2 — Test conducted on: 29.7.2003

Wells

Discharge 7.15 l/s



Transmissivity [m²/min]: 2.84 x 10^{-2}

Storativity: 7.62 x 10^{-7}

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160 Columbia St. W.
Waterloo, Ontario, Canada
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Pumping test analysis
Recovery method after
THEIS & JACOB
Confined aquifer

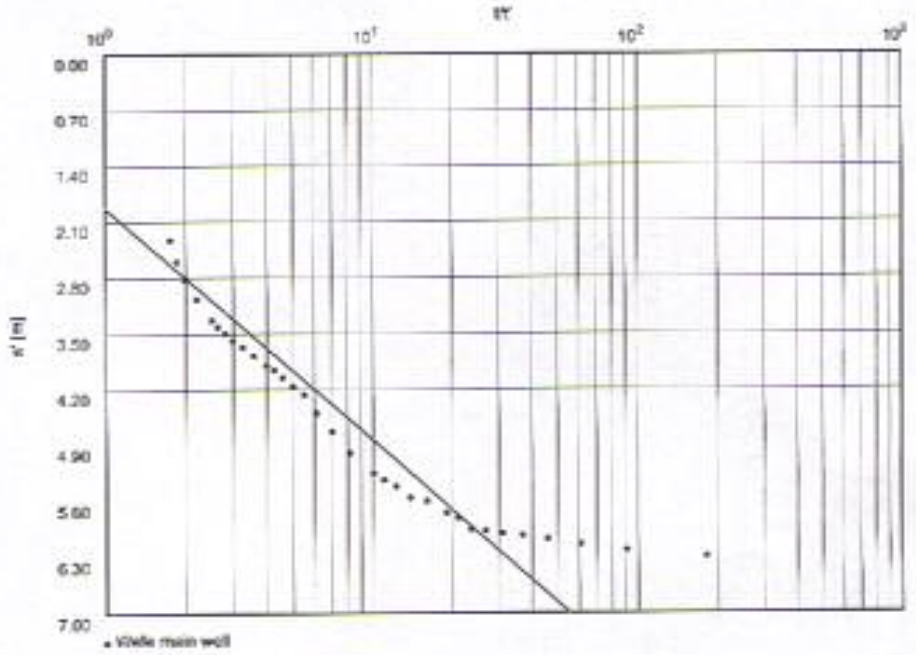
Date: 11.05.2003 | Page 1
Project: USAID-CEDA
Evaluated by: Gobachew Alefe

Pumping Test No. 2 — Test conducted on: 29.7.2003

Wefe

Discharge 7.15 l/s

Pumping test duration: 180.09 min



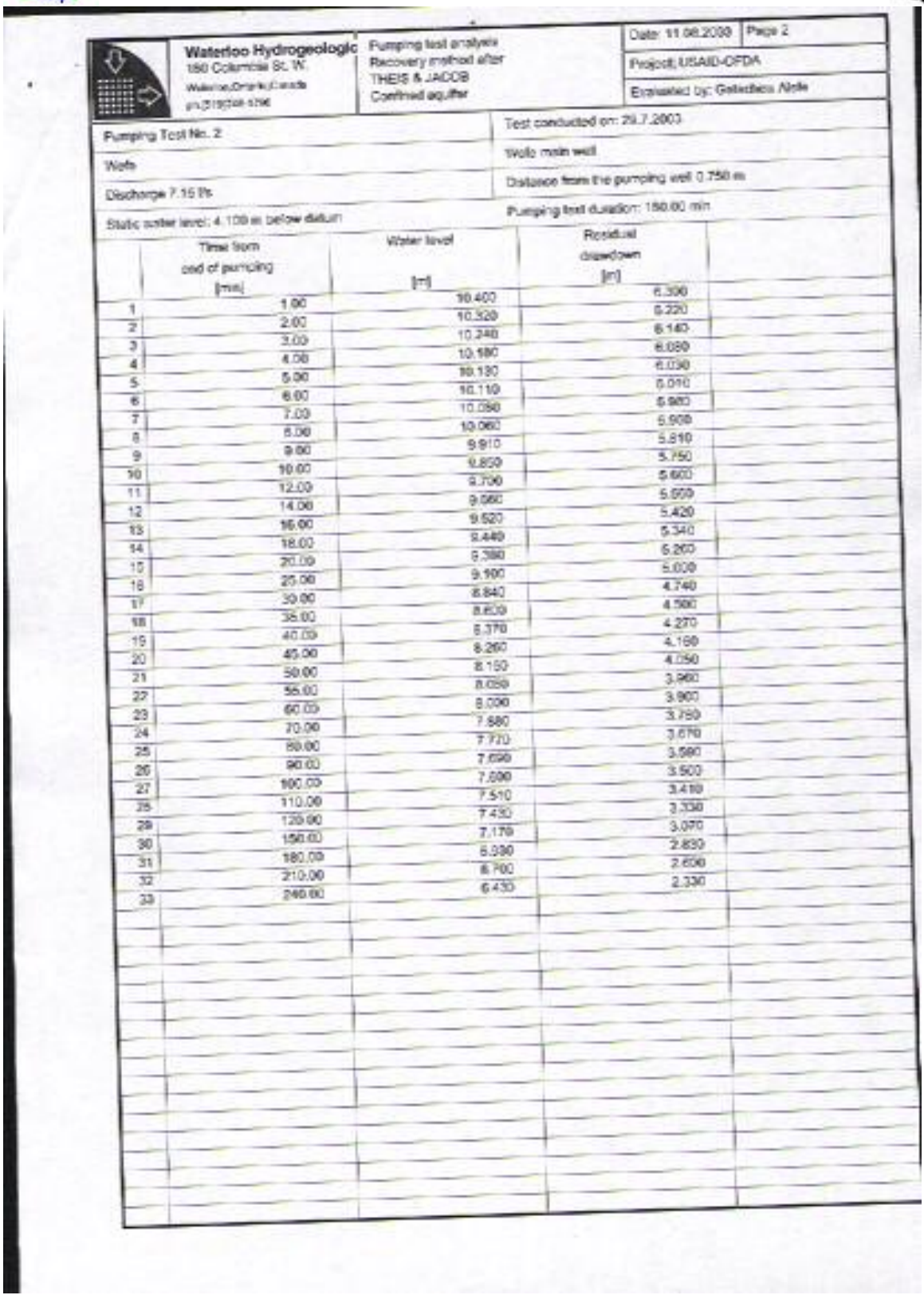
Transmissivity [m²/sec]: 2.70×10^{-2}

Waterloo Hydrogeologic 180 Columbia St. W. Waterloo, Ontario, Canada ph (519)746-1798	Pumping test analysis Time-Drawdown method after COOPER & JACOB Confined aquifer	Date: 11.08.2003	Page 2
		Project: USAID-OFDA	
		Evaluated by: Getachew Alefe	

Pumping Test No. 2	Test conducted on: 29.7.2003
Wells	Wells main well
Discharge 7.15 l/s	Distance from the pumping well 0.700 m

Static water level: 4.100 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]
1	1.00	4.930	0.800
2	2.00	4.300	0.200
3	3.00	4.370	0.270
4	4.00	4.450	0.350
5	5.00	4.540	0.440
6	6.00	4.610	0.510
7	7.00	4.680	0.580
8	8.00	4.770	0.670
9	9.00	4.840	0.740
10	10.00	4.910	0.810
11	12.00	5.050	0.950
12	14.00	5.150	1.050
13	16.00	5.240	1.140
14	18.00	5.350	1.250
15	20.00	5.480	1.380
16	25.00	5.650	1.550
17	30.00	5.840	1.740
18	35.00	6.030	1.930
19	40.00	6.170	2.070
20	45.00	6.320	2.220
21	50.00	6.500	2.400
22	55.00	6.620	2.520
23	60.00	6.770	2.670
24	70.00	7.070	2.970
25	80.00	7.320	3.220
26	90.00	7.550	3.450
27	100.00	7.800	3.700
28	110.00	8.060	3.960
29	120.00	8.520	4.420
30	150.00	10.150	6.050
31	180.00	10.450	6.300



Waterloo Hydrogeologic 160 Columbia St. W. Waterloo,Ontario,Canada ph.(519)746-1798	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 11.08.2009	Page 2
		Project: USAID-OFDA	
		Evaluated by: Gelledhess Ahrle	

Pumping Test No. 2	Test conducted on: 29.7.2003
Wells	Wells main well
Discharge 7.15 l/s	Distance from the pumping well 0.750 m
Static water level: 4.109 m below datum	Pumping test duration: 180.00 min

	Time from start of pumping [min]	Water level [m]	Residual drawdown [m]
1	1.00	10.400	6.300
2	2.00	10.320	6.220
3	3.00	10.240	6.140
4	4.00	10.180	6.080
5	5.00	10.130	6.030
6	6.00	10.110	6.010
7	7.00	10.080	5.980
8	8.00	10.060	5.960
9	9.00	9.910	5.810
10	10.00	9.859	5.750
11	12.00	9.709	5.600
12	14.00	9.660	5.550
13	16.00	9.520	5.420
14	18.00	9.440	5.340
15	20.00	9.380	5.280
16	25.00	9.190	5.090
17	30.00	8.840	4.740
18	35.00	8.690	4.590
19	40.00	8.370	4.270
20	45.00	8.260	4.160
21	50.00	8.150	4.050
27	55.00	8.059	3.960
23	60.00	8.000	3.900
24	70.00	7.880	3.780
25	80.00	7.770	3.670
26	90.00	7.690	3.590
27	100.00	7.600	3.500
28	110.00	7.510	3.410
29	120.00	7.450	3.350
30	150.00	7.179	3.070
31	180.00	6.930	2.830
32	210.00	6.700	2.600
33	240.00	6.430	2.330

HAND DUG WELLS WITH HAND PUMP ONLY

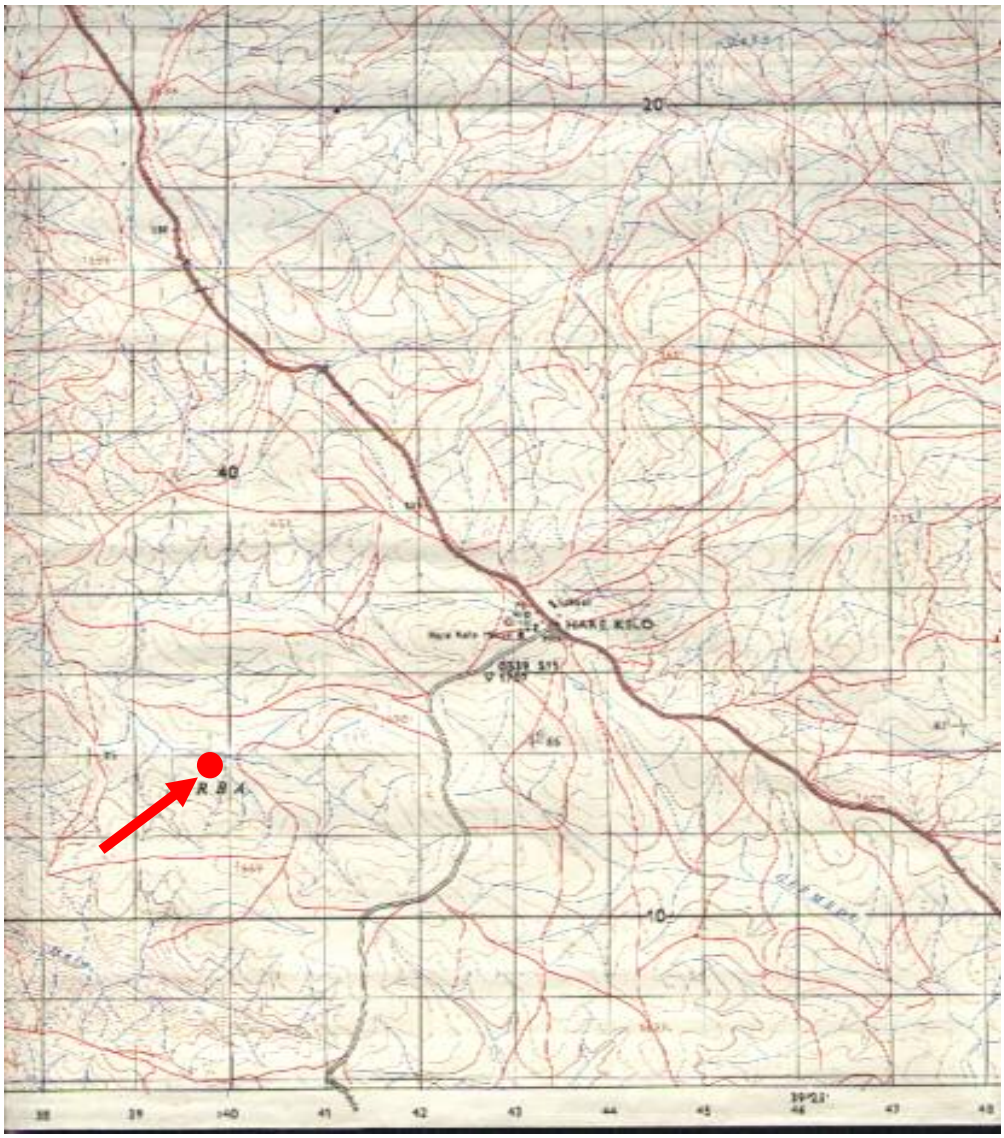
3-Sirba

3-1 Location

The site locate by south west of Harekelo village, and it accessible by dry whether road. It fars 4km and 39 km from Harekelo and Negele, respectively. In UTM geographic system the site appear at:

Zone 37N
North 612309m
East 539822m

Location Map of Sirba
Adapted from 1:50,000 topographic map
Of HareKelo
Sheet no 0539 A4



3-2 Well excavation work

Well excavation work started in July, 2002. The excavation work succeeded with a number of trials to over come the encountered caving problem. Initially the excavation work progressed smoothly up to the depth of 3.2m, but due to high amount of water the well caved up to depth of 1.4m. It was tried to maintain the well by clearing the collapsed sandy material; however the attempt failed because of the increasing collapsing rate.

In order to with stand the problem the site shifted to few meters from the previous, and the excavation work also modified to telescopic way. The same problem encountered with the new technique and once again the site shifted to other place in near by.

The excavation on the third place carried out with the help of 2.2m width sheet iron casing to retain the collapsing layer and the excavation work completed successfully on June 28, 2002 using the technique. Water stroke at the depth of 1.4m and the final depth of the well is 5.4m.

3-3 casing

Blind as well as slotted concrete ring casings were lowered in to the well according to the following order from the ground level:

Blind 0 up to 1m
Screen (slotted rings) 1m up to end depth i.e. 5.4m.

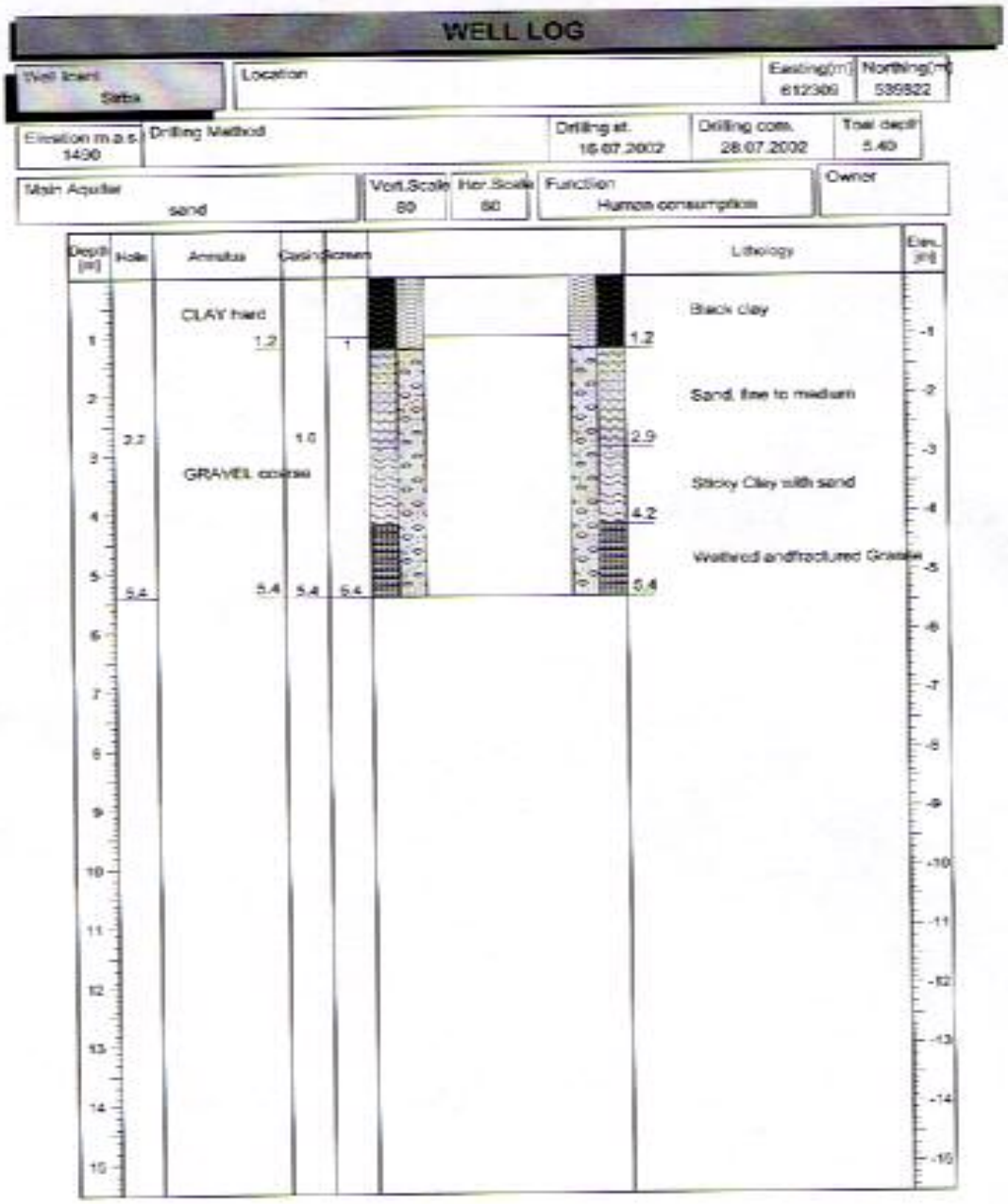
The ring is further rise 0.60m above ground level to prevent flooding and to permit the well head structure. The diameter of the rings is same and it is 1.5 in the internal part and 1.7m in the outer part.

3-4 Packing

The well annular space packed by selected river gravel from the depth of 1m up to the bottom of the well to facilitate the in flow of water into the well and to server as filtering media. The rest part of the well was packed by clay in order to prevent the percolation of water in to the well.

3-5 Well log

Samples were continuously observed in order to identify the lithological layering and the samples are used to set the well log. The well lithological log and the well casing as well as packing design are shown on the following chart.


WELL LOG
Well Ident
Saba
Location
Easting(m)
612386
Northing(m)
539822
Elevation m.a.s.l.
1490
Drilling Method
Drilling st.
16.07.2002
Drilling com.
28.07.2002
Total depth
5.40
Main Aquifer
sand
Vert.Scale
80
Hor.Scale
80
Function
Human consumption
Owner
Depth [m]
Hole
Annulus
Casing
Screen
Lithology
Elev. [m]
CLAY hard
1.2
GRAVEL coarse
2.2
1.0
5.4
Black clay
Sand, fine to medium
Sticky Clay with sand
Weathred and fractured Gneiss

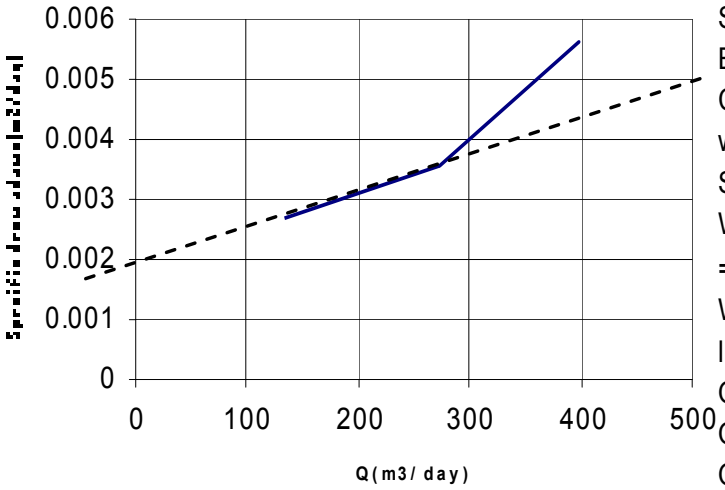
3-6 Pumping test

It was intended to carry out Extended Drawdown Pumping test, based on the preliminary information obtained about the productivity of the aquifer during well excavation work. However, due to rapid drawdown encountered during steps-four of the test, the pumping test interrupted after 155min from the commencement of the work.

The data collected during the mentioned period could be help full to understand the nature of the well in respect to its construction as well as the productivity. The data acquired as well as the interpretation result summarized in the following consecutive tables.

Date 27/08/02
Location: Zone Borena
District Liben
Kebele Sirba

Step drawdawn test
SWL 2.86
Ref.Point 70cm A.G.L
Avilable DD 2.66



S/Q=B+CQ
B=Aquifer loss=0.0018
C=well loss=0.000066 shows the well need no further development
S/Q=0.0018+0.000066Q
Well efficiency
$=(BQ/(BQ+CQ^2))*100$
Well efficiency At different pumping level
Q(1.52)=94.72%
Q(3.13)=89.71%
Q(4.55)=85.70%

Waterloo Hydrogeologic
160 Columbia St. W.
Waterloo, Ontario, Canada
N2L 3L3 519-746-1798

Pumping test analysis
Time-Drawdown plot
with discharge

Date: 29.08.2002 | Page: 1

Project: USAID-OFDA

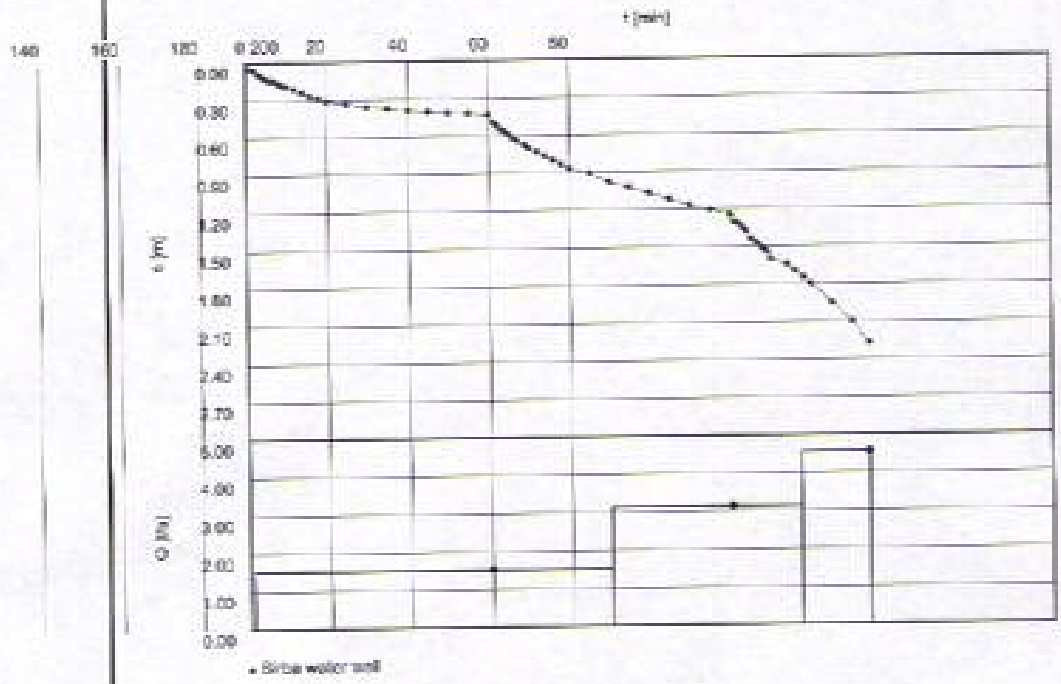
Evaluated by: Getachew Alole

Pumping Test No. 1

Test conducted on: 17.08.2002

Sirba

Discharge 2.35 l/s



Waterloo Hydrogeologic
Pumping test analysis
Time-Drawdown plot
with discharge

Date: 25/02/08 | Page 1

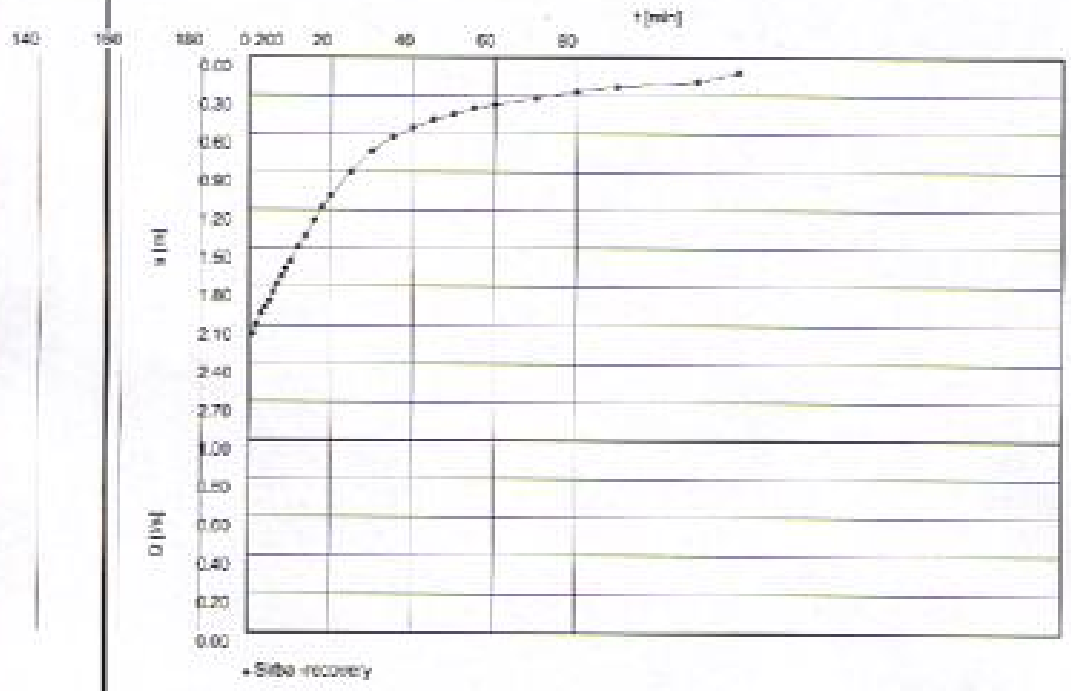
Project: Drought consequence al...

Evaluated by: Gebchea

Pumping Test No. 2

Test conducted on: 27/05/02

Sibut



Waterloo Hydrogeologic 160 Columbia St. W. Waterloo, Ontario, Canada ph.(519)746-1798	Pumping test analysis Time-Drawdown plot	Date: 28.08.2002 Page 2 Project: USAID-OFDA Evaluated by: Getachew Asfa
Pumping Test No. 1		Test concluded on: 27.08.2002
Sitka		Sitka Water well

Static water level: 2.790 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]
1	1.00	2.810	0.050
2	2.00	2.820	0.060
3	3.00	2.850	0.090
4	4.00	2.870	0.110
5	5.00	2.890	0.130
6	6.00	2.900	0.140
7	7.00	2.910	0.150
8	8.00	2.920	0.160
9	9.00	2.940	0.180
10	10.00	2.950	0.190
11	12.00	2.970	0.210
12	14.00	3.000	0.240
13	16.00	3.030	0.270
14	18.00	3.050	0.290
15	20.00	3.070	0.310
16	25.00	3.090	0.330
17	30.00	3.120	0.360
18	35.00	3.130	0.370
19	40.00	3.150	0.390
20	45.00	3.160	0.400
21	50.00	3.170	0.410
22	55.00	3.180	0.420
23	60.00	3.190	0.430
24	61.00	3.200	0.440
25	62.00	3.260	0.500
26	63.00	3.310	0.550
27	64.00	3.330	0.570
28	65.00	3.350	0.590
29	66.00	3.360	0.600
30	67.00	3.400	0.640
31	68.00	3.420	0.660
32	69.00	3.440	0.680
33	70.00	3.460	0.700
34	72.00	3.490	0.730
35	74.00	3.520	0.760
36	76.00	3.560	0.800
37	78.00	3.590	0.830
38	80.00	3.630	0.870
39	85.00	3.670	0.910
40	90.00	3.740	0.980
41	95.00	3.790	1.030
42	100.00	3.830	1.070
43	105.00	3.880	1.120
44	110.00	3.920	1.170
45	115.00	3.970	1.210
46	120.00	4.010	1.250
47	121.00	4.070	1.310
48	122.00	4.090	1.330
49	123.00	4.130	1.360
50	124.00	4.140	1.380

Waterloo Hydrogeologic 180 Columbia St. W. Waterloo,Ontario,Canada ph (519)746-1356	Pumping test analysis Time-Drawdown plot	Date: 28.06.2002 | Page: 1 Project: USAID-OFDA Evaluated by: Getachew Asfa
Pumping Test No: 1		Test conducted on: 27.06.2002
Shola		Sitbe Water well

Static water level: 2.750 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]
51	125.00	4.200	1.440
52	126.00	4.200	1.450
53	127.00	4.200	1.450
54	128.00	4.260	1.520
55	129.00	4.350	1.610
56	130.00	4.300	1.550
57	134.00	4.410	1.660
58	136.00	4.460	1.700
59	138.00	4.510	1.750
60	140.00	4.550	1.800
61	142.00	4.710	1.960
62	150.00	4.850	2.100
63	153.00	5.000	2.240
64	154.00	5.030	2.270
65	155.00	4.950	2.190
66	156.00	4.970	2.210
67	157.00	4.820	2.060
68	158.00	4.770	2.010
69	159.00	4.760	1.940
70	160.00	4.640	1.890
71	161.00	4.580	1.820
72	162.00	4.520	1.760
73	163.00	4.460	1.700
74	165.00	4.360	1.590
75	167.00	4.260	1.500
76	169.00	4.140	1.350
77	171.00	4.040	1.250
78	173.00	3.960	1.190
79	176.00	3.760	1.000
80	183.00	3.600	0.840
81	188.00	3.490	0.730
82	193.00	3.410	0.650
83	198.00	3.350	0.590
84	203.00	3.310	0.550
85	208.00	3.260	0.500
86	213.00	3.220	0.470
87	223.00	3.180	0.420
88	233.00	3.139	0.379
89	243.00	3.090	0.330
90	253.00	3.080	0.320
91	263.00	3.050	0.290
92	273.00	2.980	0.220
93	303.00	2.980	0.120

3-7 Water quality

Water sample had taken in the end period of the pumping test. The water sample physically looks colorless, odorless and not saline. The sample also tested for some drinking water quality parameters and the result obtained from the test listed below.

Conductivity	1310 µs/cm
Temperature	23.8^0c
Total Hardness	Hard 516.2 PPM $CaCO_3$
Chloride Cl-	100mg/lit
Ph	7.5
Ammonium	-
Chloride	175mg/lit
Nitrate	-
Sulfate	<200ppm

3-8 Well head and fencing

The well head constructed on the well is the usual COOPI standard well head i.e. 4m*4m with concrete slab on top. First the structure rise from the ground to sufficient height (average=0.60m) by masonry and on top covered by reinforced concrete slab with manhole and inlet hole for both hand pump.

After the well head construction *INDIAN MARK II* hand pump installed, and finally the well site fenced by barbed wire with support of angle iron.

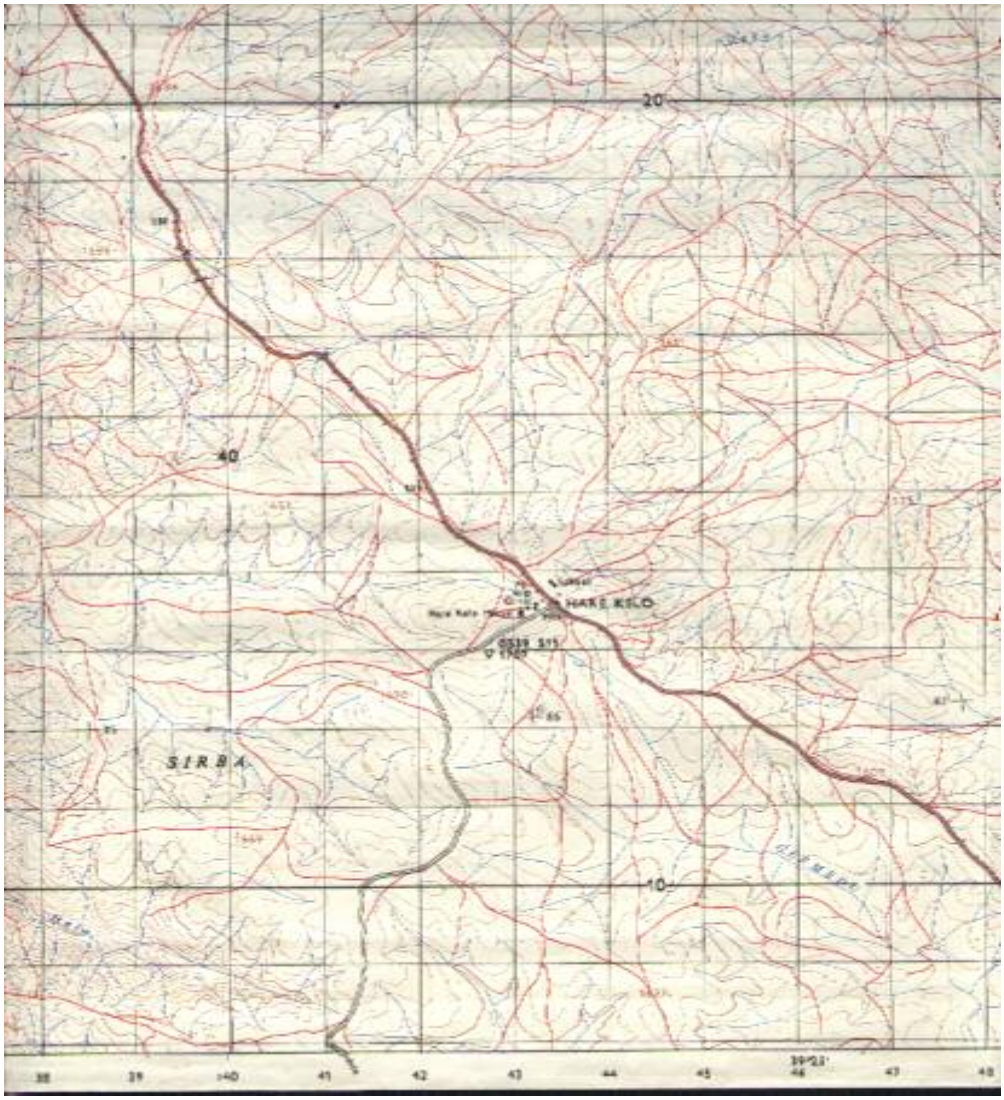
4- Mucho

4-1 Location

The site located by north of Harekelo and it accessible dry ether access road. The selected site of water intervention is far 13Km from Harekelo, and it far 48km from Negele towards North. In UTM geographic coordinate system the place where the well located appears at:

Zone 37N
North 619863m
East 541167m

Location Map of Mucho
Adapted from 1:50,000 topographic map
Of HareKelo
Sheet no 0539 A4



4-2 Well excavation

Well excavation work started in July, 2002 and completed on September19, 2002. The diameter of the well was 2.2m, and the final depth of the well is 14.85m. Water stroke at the depth of 6.6m and the static water level inside the well is 6.62m. The main aquifer of the well is sand, and the layer below the sand layer is also water bearing. In general the excavation work at Mucho completed with no major trouble.

4-3 casing

Blind as well as slotted concrete ring casings were lowered in to the well according to the following order from the ground level:

Blind 0 up to 7.85m
Screen (slotted rings) 7.85m up to end depth i.e. 14.85m.

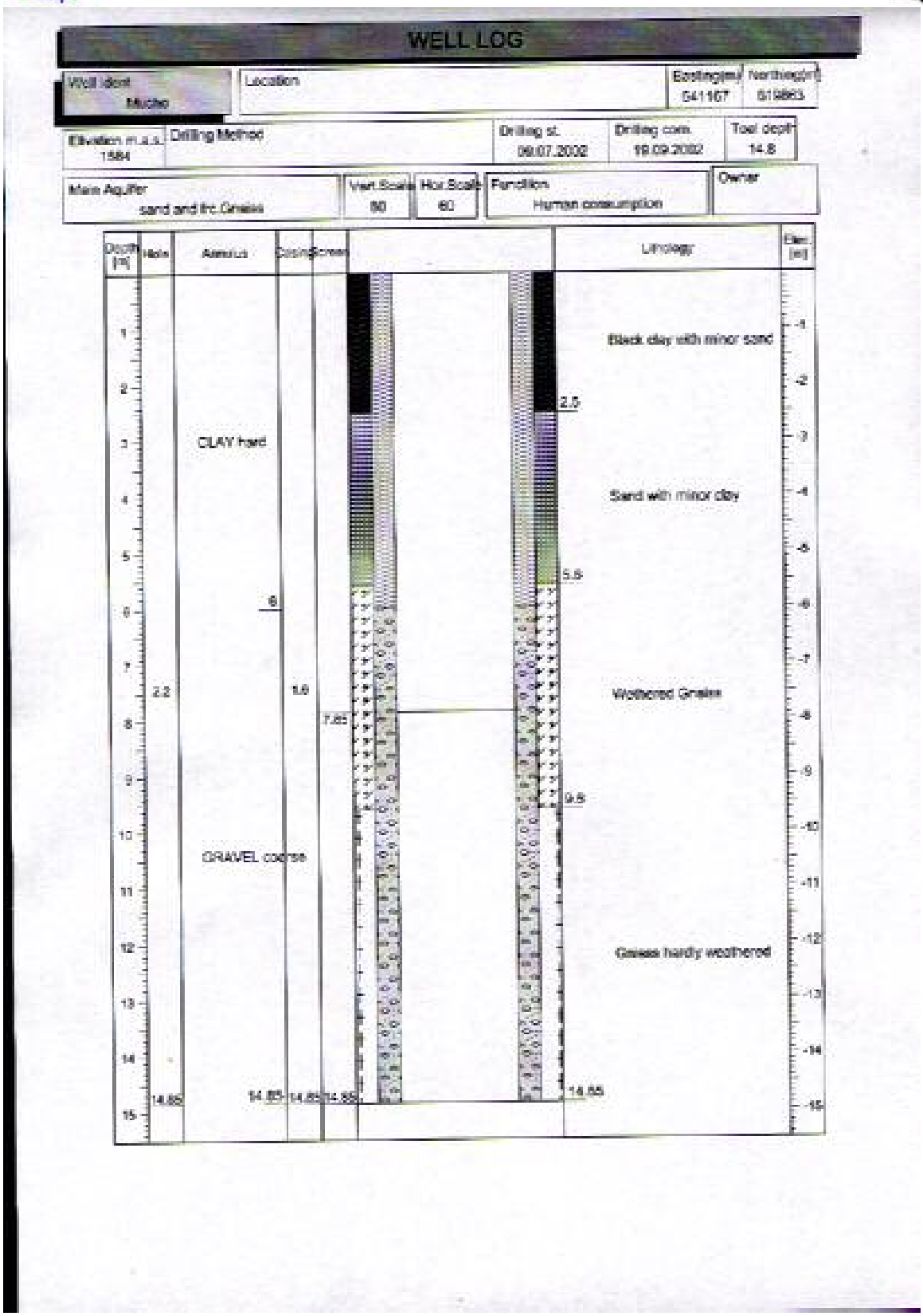
The ring is further rise 0.60m above ground level to prevent flooding and to permit the well head structure. The diameter of the rings is same for all and it is 1.5 in the internal part and 1.7m in the outer part.

4-4 Packing

The well annular space packed by selected river gravel from the depth of 6m up to the bottom of the well to facilitate the in flow of water into the well and to server as filtering media. The rest part of the well was packed by clay in order to prevent the percolation of surface water in to the well.

4-5 Well log

Samples were continuously observed in order to identify the lithological layering and the samples are used to set the well log. The well lithological log and the well casing as well as packing design are shown on the following chart.


WELL LOG
Well Ident
Mucho
Location
Eastings(m)
041167
Northings(m)
519863
Elevation m.a.s.l.
1584
Drilling Method
Drilling st.
09.07.2002
Drilling com.
19.09.2002
Total depth
14.8
Main Aquifer
sand and frc.Gneiss
Vert.Scale
50
Hor.Scale
50
Function
Human consumption
Owner
Depth [m]
Holes
Annulus
Casing
Screen
Litology
Elev. [m]
Black clay with minor sand
2.5
CLAY hard
Sand with minor clay
5.5
6
2.2
1.6
7.85
Weathered Gneiss
9.5
GRAVEL coarse
Gneiss hardly weathered
14.85
14.85
14.85
14.85
14.85

4-6 Pumping test

Constant discharge test was adapted for the well test. The test carried out for total of 6 hours and the result obtained from the test used in Cooper and Jacob equations to calculate transimisivity. The general information regarding the test and the result obtained are presented below.

Date of test 30/09/2002
Location: Zone Borena
District Liben
Kebele Mucho

Constant Dicharge Test
SWL 6.62
Ref.Point 70cm A.G.L
Q(lit/sec) 0.91

4-7 Water quality

Water sample had taken in the end period of the pumping test. The water sample physically looks colorless and not saline. The sample also tested for some drinking water quality parameters and the result obtained from the test listed below.

Conductivity	558 µs/cm
Temperature	20.8^0c
Total Hardness	soft
Chloride Cl-	100mg/lit
Ph	9
Ammonium	1mg/lit
Nitrite	-
Sulfate	<200ppm

4-8 Well head and fencing

The well head constructed on the well is the usual COOPI standard well head i.e. 4m*4m with concrete slab on top. First the structure rise from the ground to sufficient height (average=0.60m) by masonry and on top covered by reinforced concrete slab with manhole and inlet hole for both hand pump.

After the well head construction *INDIAN MARK II* hand pump installed, and finally the well site fenced by barbed wire with support of angle iron.

Waterloo Hydrogeologic
180 Columbia St. W
Waterloo,Ontario,Canada
ph.(519)746-1798

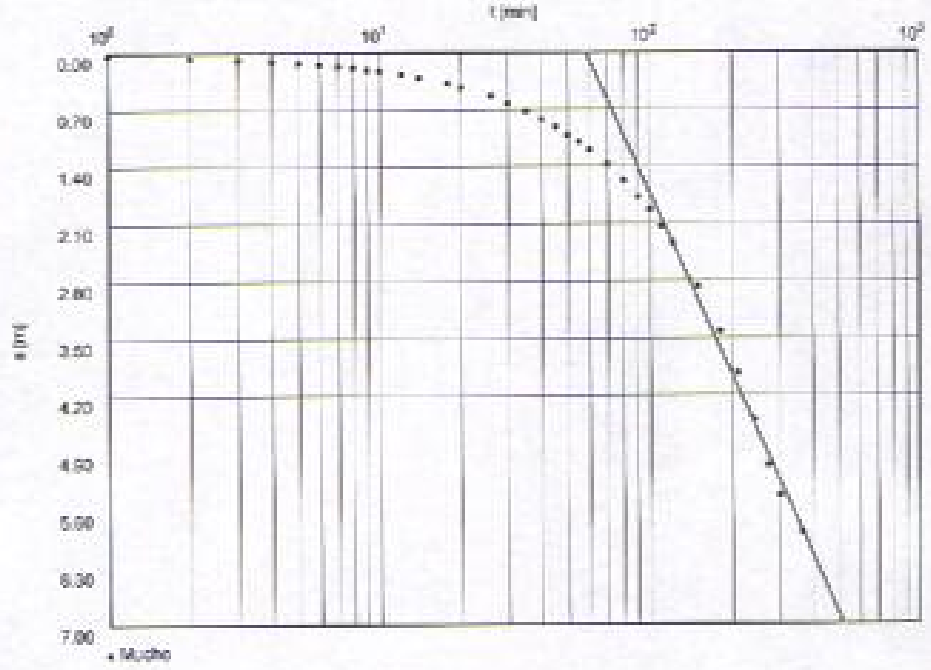
Pumping test analysis
Time-Drawdown-method after
COOPER & JACOB
Confined aquifer

Date: 01/10/2002 | Page: 1
Project: COOPI- USAID Project
Evaluated by: Gelachew

Pumping Test No. 1 | Test conducted on: 30/10/02

Mucho

Discharge: 0.56 l/s



Transmissivity [m²/min]: 1.42×10^{-2}

Storativity: 2.32×10^{-1}

Waterloo Hydrogeologic 180 Columbia St. W. Waterloo, Ontario, Canada ph (519) 746-1798	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 01/10/2002 | Page 2 Project: COOPI- USAID Project Evaluated by: Getachew

Pumping Test No. 1	Test conducted on: 30/1/02
Mudiko	Macro
Discharge 0.99 l/s	Distance from the pumping well: 0.750 m

Static water level: 6.629 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]
1	1.00	6.669	0.040
2	2.00	6.699	0.070
3	3.00	6.719	0.090
4	4.00	6.739	0.110
5	5.00	6.759	0.130
6	6.00	6.779	0.150
7	7.00	6.799	0.170
8	8.00	6.819	0.190
9	9.00	6.839	0.210
10	10.00	6.859	0.230
11	12.00	6.899	0.270
12	14.00	6.939	0.310
13	16.00	7.009	0.359
14	20.00	7.069	0.439
15	25.00	7.159	0.530
16	30.00	7.259	0.630
17	35.00	7.349	0.720
18	40.00	7.449	0.820
19	45.00	7.549	0.920
20	50.00	7.649	1.020
21	55.00	7.729	1.100
22	60.00	7.829	1.200
23	70.00	8.009	1.380
24	80.00	8.209	1.580
25	90.00	8.399	1.770
26	100.00	8.559	1.930
27	110.00	8.759	2.130
28	120.00	8.959	2.330
29	150.00	9.499	2.870
30	180.00	10.049	3.420
31	210.00	10.559	3.930
32	240.00	11.129	4.500
33	270.00	11.689	5.060
34	300.00	12.059	5.430
35	360.00	12.509	5.880

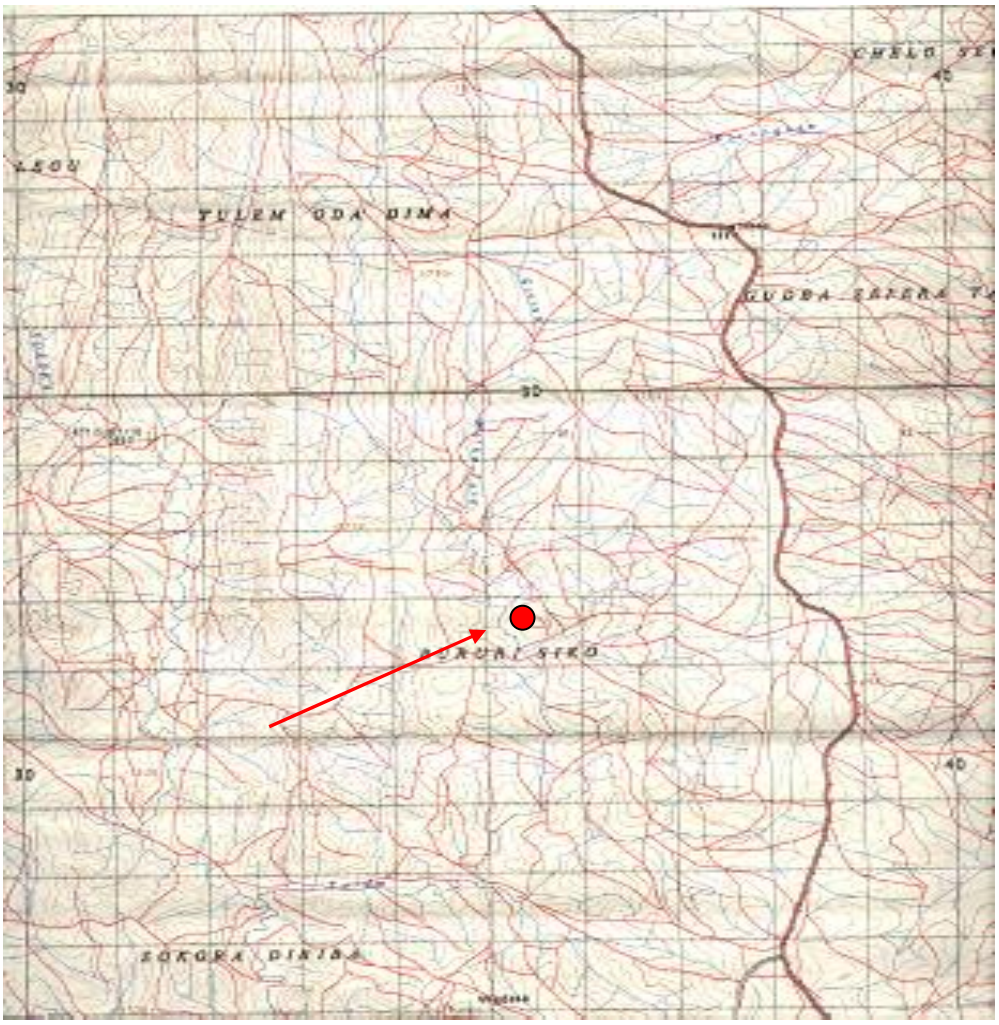
5- Dolcha

5-1 Location

The site located by north of Harekelo and it accessible dry ether access road. The selected site of water intervention is far 19Km from Harekelo, and it far 54km from Negele towards North. In UTM geographic coordinate system the place where the well located appears at:

Zone 37N
North 626696m
East 535365m

Location Map of Dolcah
Adapted from 1:50,000 topographic map
Sheet no 0539 A4
Of HareKelo



5-2 Well excavation

Well excavation work started in November, 2002 and completed on January 16, 2002. The diameter of the well was 2.2m, and the final depth of the well is 8.5m. Water stroke at the depth of 4.6m and the static water level inside the well is 4.4m below ground level. The main aquifer of the well is fractured biotite gneiss, and the excavation work at Dolcha finalized with no major trouble.

5-3 casing

Blind as well as slotted concrete ring casings were lowered in to the well according to the following order from the ground level:

Blind 0 up to 3.5m
Screen (slotted rings) 3.5m up to end depth i.e. 8.5m.

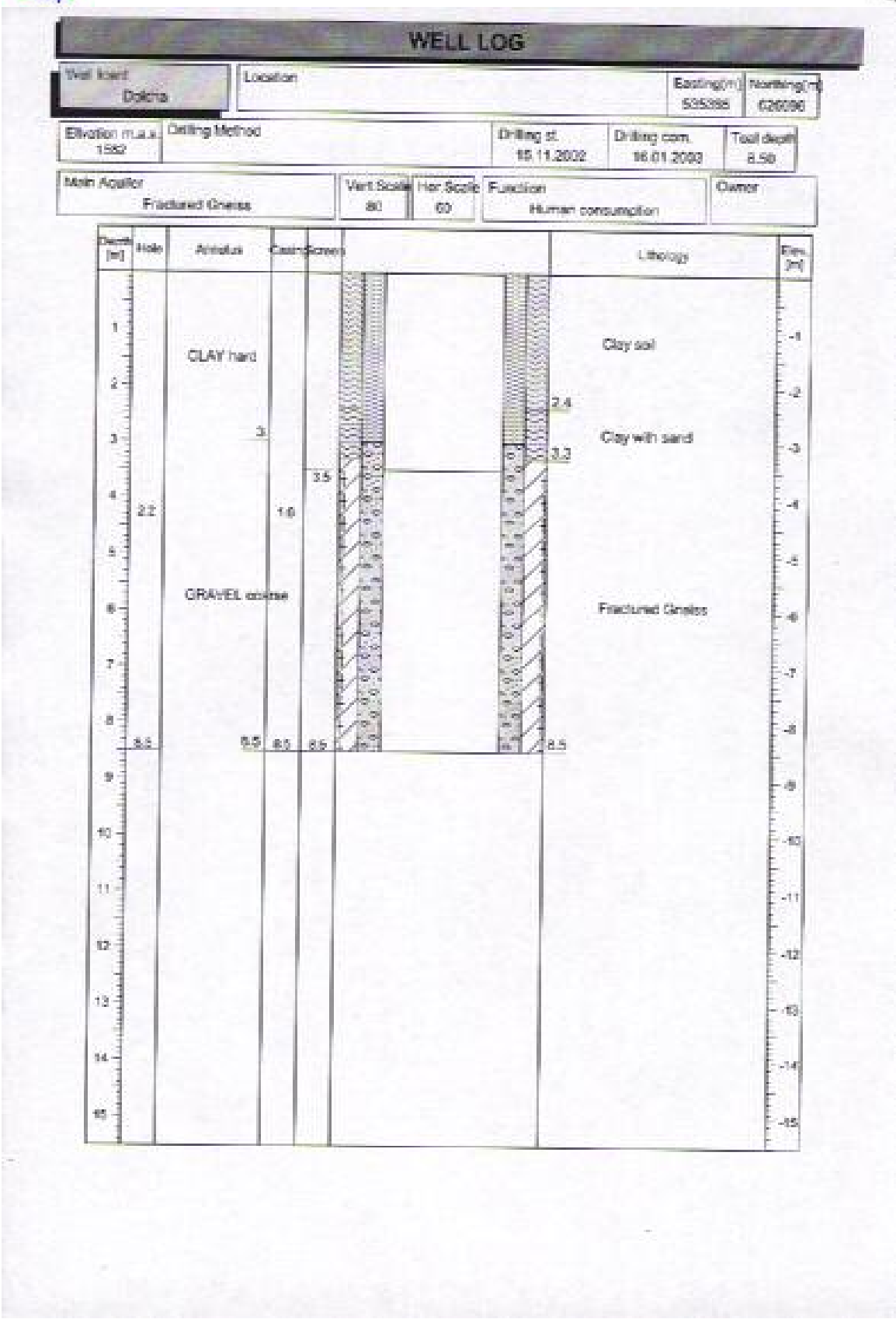
The ring is further rise 0.60m above ground level to prevent flooding and to permit the well head structure. The diameter of the rings is same for all and it is 1.5 in the internal part and 1.7m in the outer part.

5-4 Packing

The well annular space packed by selected river gravel from the depth of 3m up to the bottom of the well to facilitate the in flow of water into the well and to server as filtering media. The rest part of the well was packed by clay in order to prevent the percolation of surface water in to the well.

5-5 Well log

Samples were continuously observed in order to identify the lithological layering and the samples were used to set the well log. The well lithological log and the well casing as well as packing design are shown on the following chart.


WELL LOG
Well Ident
Dolcha
Location
Easting(m)
535386
Northing(m)
626090
Elivation m.a.s.l
1582
Drilling Method
Drilling st.
15.11.2002
Drilling com.
16.01.2003
Tool depth
8.50
Main Aquifer
Fractured Gneiss
Vert Scale
80
Hor Scale
60
Function
Human consumption
Owner
Depth [m]
Hole
Annulus
Casing
Screen
Lithology
Elev. [m]
CLAY hard
GRAVEL coarse
Clay soil
Clay with sand
Fractured Gneiss
2.2
3
1.0
3.5
2.4
3.2
8.5
8.5
8.5
8.5

5-6 Pumping test

Constant discharge test was adapted for the well test. The test carried out for total of 7 hours including the recovery test, and the data obtained from the test is used in Cooper and Jacob equations to calculate transimisivity. Theis and Cooper method applied for the recovery test. The general information regarding test listed below, and the result obtained from the analysis are presented in the next consecutive pages.

Date of test 14/04/2003	Constant Discharge Test
Location: Zone Borena	SWL 5.4
District Liben	Ref.Point 1.0m A.G.L
Kebele Dolcha	Q(m^3/day) 46.84

5-7 Water quality

Water sample had taken in the end period of the pumping test. The water sample physically looks colorless and not saline. The sample also tested for some drinking water quality parameters and the result obtained from the test listed below.

Conductivity	1081 µs/cm
Temperature	23^0c
Total Hardness	Medium Hard
Chloride Cl-	150mg/lit
Ph	7
Ammonium	nill
Nitrite	nill
Sulfate	<200ppm

5-8 Well head and fencing

The well head constructed on the well is the usual COOPI standard well head i.e. 4m*4m with concrete slab on top. First the structure rise from the ground to sufficient height (average=1:0m) by masonry and on top covered by reinforced concrete slab with manhole and inlet hole for hand pump.

After the well head construction *INDIAN MARK II* hand pump installed, and finally the well site fenced by barbed wire with support of angle iron.

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180 Columbia St. W.
Waterloo, Ontario Canada
ph (519)746-1798

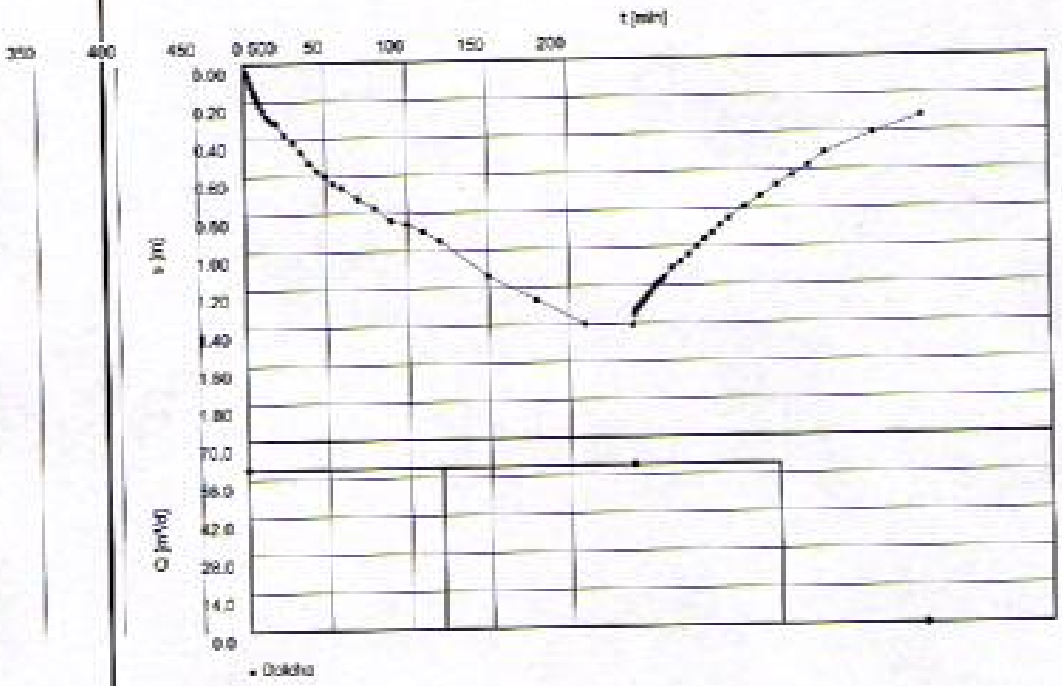
Pumping test analysis
Time Drawdown plot
with discharge

Date: 17.04.1903 | Page: 1
Project: USAID
Evaluated by: Getachew A.

Pumping Test No.: 1
Test conducted on: 14-04-1903

Dokdka

Discharge 48.84 m³/d



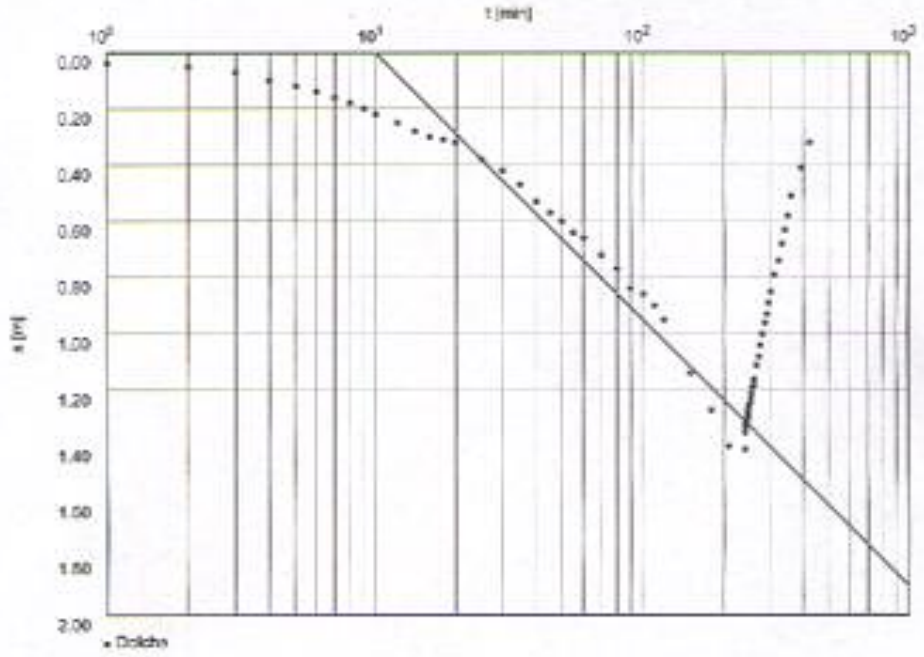
Waterloo Hydrogeologic Pumping test analysis
Time-Drawdown-method after
COOPER & JACOB
Confined aquifer

Project: USAID
Evaluated by: Getachew A.

Pumping Test No: 1
Test conducted on: 14-04-1993

Dolicha

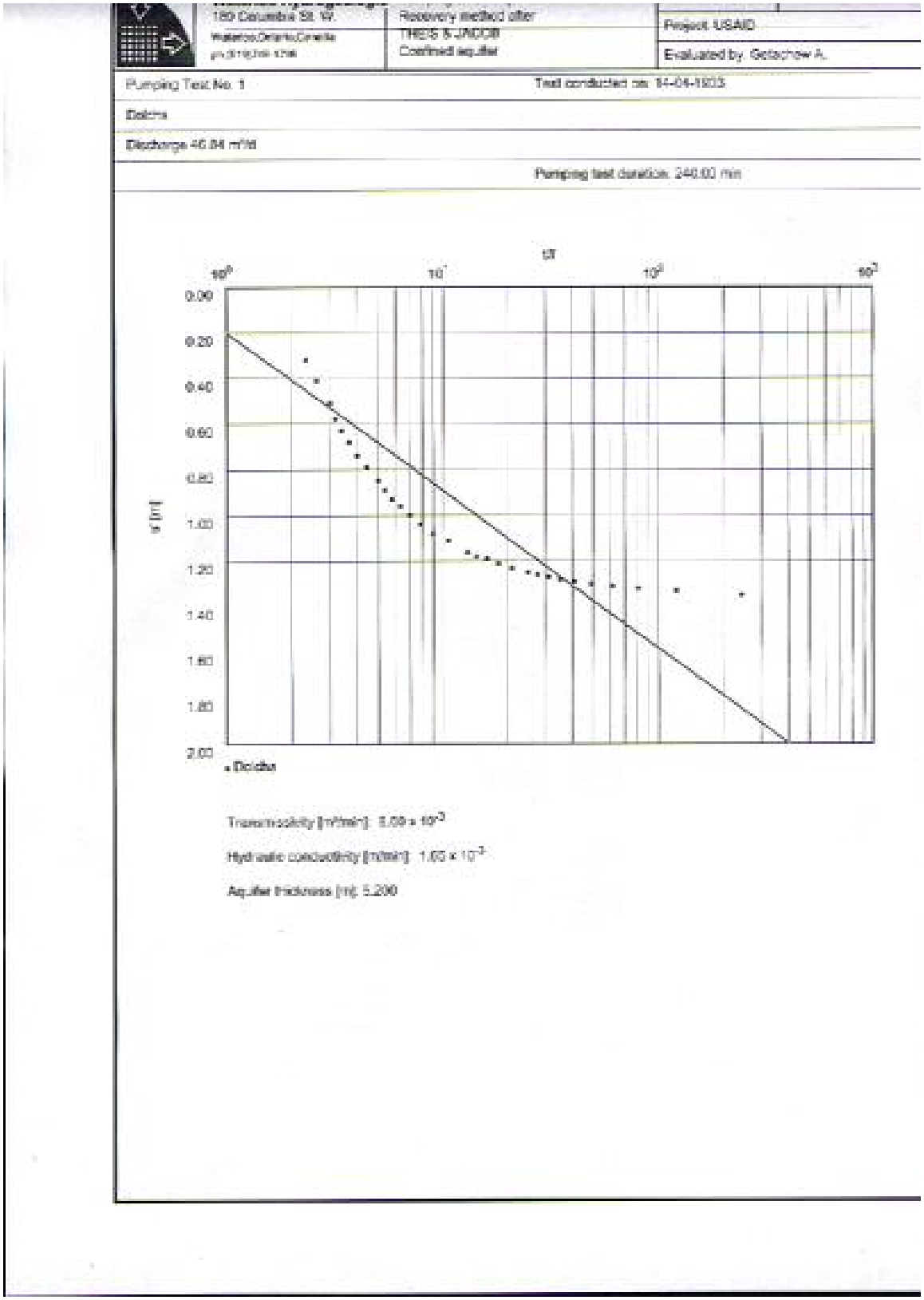
Discharge 46.84 m³/d



Transmissivity [m²/min]: 0.28×10^{-3}

Storativity: 2.49×10^{-3}

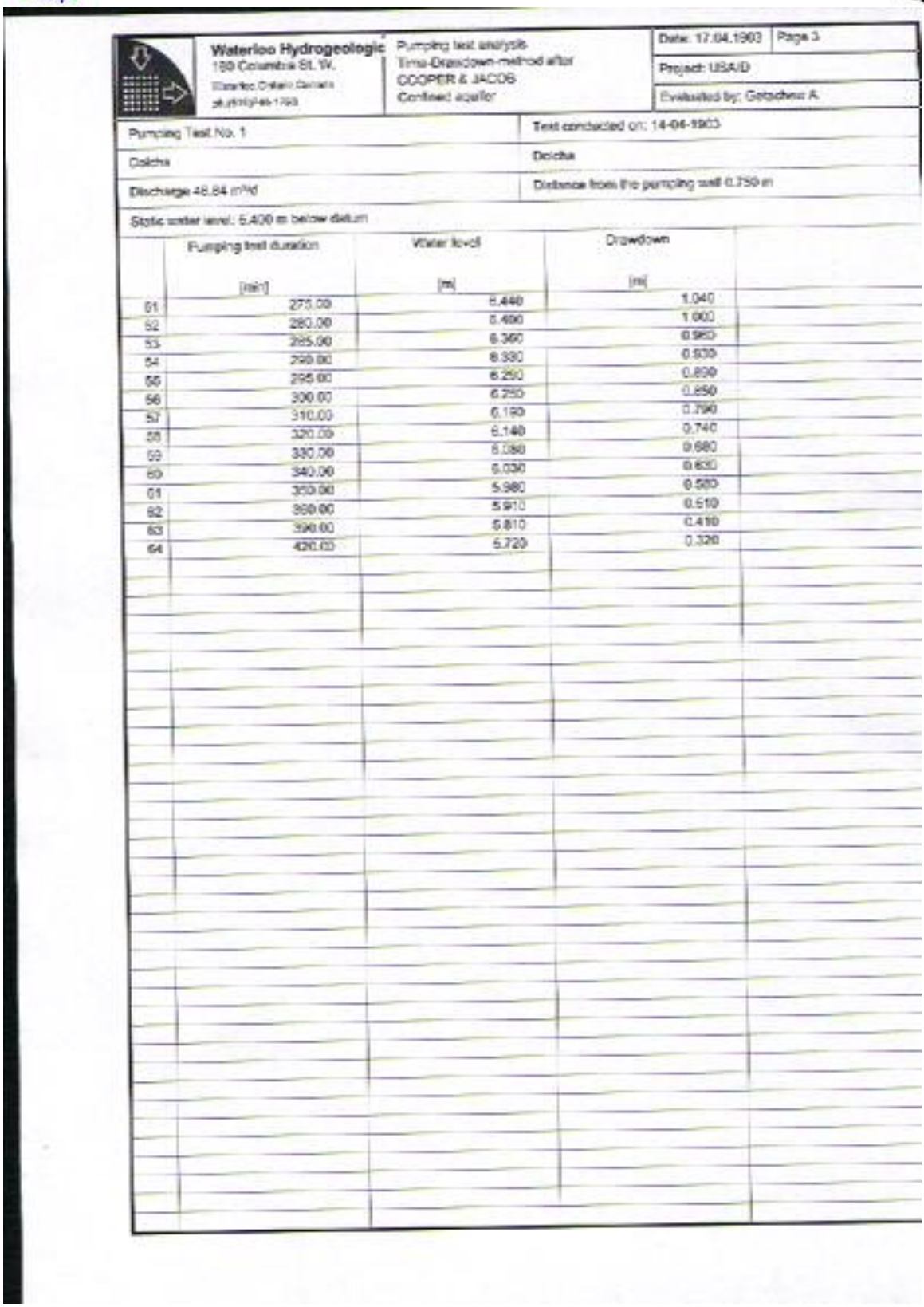
* water level measured at the pumping well
*After 240min pumping stopped


Recovery method after
THEIS & JACOB
Confined aquifer
Project: USAID
Evaluated by: Getachew A.
Pumping Test No: 1
Test conducted on: 14-04-1993
Dalchs
Discharge 46.84 m³/d
Pumping test duration: 240.00 min
t/t'
s' [m]
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
Dalchs
Transmissibility [m²/min]: 5.09 x 10⁻³
Hydraulic conductivity [m/min]: 1.00 x 10⁻³
Aquifer thickness [m]: 5.200

Waterloo Hydrogeologic 180 Columbia St. W. Waterloo,Ontario,Canada ph(519)746-1798	Pumping test analysis Time-Drawdown-method after: COOPER & JACOB Confined aquifer	Date: 17.04.1903 Page 2 Project: USAID Evaluated by: Getachew A.

Pumping Test No. 1	Test conducted on: 14-04-1903
Dolitho	Dolitho
Discharge 46.84 m³/d	Distance from the pumping well 0.750 m
Static water level 5.460 m below datum	

	Pumping test duration [min]	Water level [m]	Drawdown [m]
1	1.00	5.449	0.040
2	2.00	5.459	0.050
3	3.00	5.470	0.070
4	4.00	5.500	0.100
5	5.00	5.520	0.120
6	6.00	5.540	0.140
7	7.00	5.550	0.150
8	8.00	5.560	0.160
9	9.00	5.580	0.200
10	10.00	5.620	0.220
11	12.00	5.650	0.250
12	14.00	5.680	0.280
13	16.00	5.700	0.300
14	18.00	5.710	0.310
15	20.00	5.720	0.320
16	25.00	5.760	0.350
17	30.00	5.820	0.420
18	35.00	5.870	0.470
19	40.00	5.930	0.530
20	45.00	5.970	0.570
21	50.00	6.000	0.600
22	55.00	6.040	0.640
23	60.00	6.080	0.680
24	70.00	6.120	0.720
25	80.00	6.170	0.770
26	90.00	6.240	0.840
27	100.00	6.280	0.880
28	110.00	6.300	0.900
29	120.00	6.350	0.950
30	150.00	6.540	1.140
31	180.00	6.670	1.270
32	210.00	6.800	1.400
33	240.00	6.810	1.410
34	241.00	6.750	1.350
35	242.00	6.750	1.350
36	243.00	6.720	1.320
37	244.00	6.710	1.310
38	245.00	6.700	1.300
39	246.00	6.660	1.260
40	247.00	6.660	1.260
41	248.00	6.670	1.270
42	249.00	6.660	1.260
43	250.00	6.650	1.250
44	252.00	6.630	1.230
45	254.00	6.610	1.210
46	256.00	6.590	1.190
47	258.00	6.590	1.190
48	260.00	6.560	1.160
49	265.00	6.570	1.170
50	270.00	6.450	1.050



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Pumping test analysis
Time-Drawdown-method after
COOPER & JACOB
Confined aquifer

Date: 17.04.1903 | Page 3
Project: USAID
Evaluated by: Getachew A.

Pumping Test No. 1 | Test conducted on: 14-04-1903
Dolicha | Dolicha
Discharge 46.84 m³/d | Distance from the pumping well 0.759 m
Static water level: 5.400 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]
51	275.00	6.440	1.040
52	280.00	6.400	1.000
53	285.00	6.360	0.960
54	290.00	6.330	0.930
55	295.00	6.290	0.890
56	300.00	6.250	0.850
57	310.00	6.190	0.790
58	320.00	6.140	0.740
59	330.00	6.080	0.680
60	340.00	6.030	0.630
61	350.00	5.980	0.580
62	360.00	5.910	0.510
63	390.00	5.810	0.410
64	420.00	5.720	0.320

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180 Columbia St. W.
Waterloo,Ontario,Canada

Pumping test analysis
Recovery method after
THEIS & JACOB
Confined aquifer

Date: 17.04.1903 | Page 2
Project: USAID
Evaluated by: Getachew A.

Pumping Test No. 1 | Test conducted on: 14-04-1903
Dolicha | Dolicha
Discharge 46.64 m³/d | Distance from the pumping well 0.750 m
Static water level: 0.400 m below datum | Pumping test duration: 240.00 min

	Time from end of pumping [min]	Water level [m]	Residual drawdown [m]
1	1.00	6.750	1.309
2	2.00	6.730	1.339
3	3.00	6.720	1.329
4	4.00	6.710	1.319
5	5.00	6.700	1.309
6	6.00	6.690	1.299
7	7.00	6.680	1.289
8	8.00	6.670	1.279
9	9.00	6.660	1.259
10	10.00	6.650	1.259
11	12.00	6.630	1.239
12	14.00	6.610	1.219
13	16.00	6.590	1.199
14	18.00	6.580	1.189
15	20.00	6.560	1.169
16	25.00	6.510	1.119
17	30.00	6.480	1.089
18	35.00	6.440	1.049
19	40.00	6.400	1.009
20	45.00	6.360	0.969
21	50.00	6.330	0.939
22	55.00	6.290	0.899
23	60.00	6.260	0.869
24	70.00	6.190	0.799
25	80.00	6.140	0.749
26	90.00	6.080	0.689
27	100.00	6.030	0.639
28	110.00	5.980	0.589
29	120.00	5.910	0.519
30	150.00	5.810	0.419
31	180.00	5.720	0.329

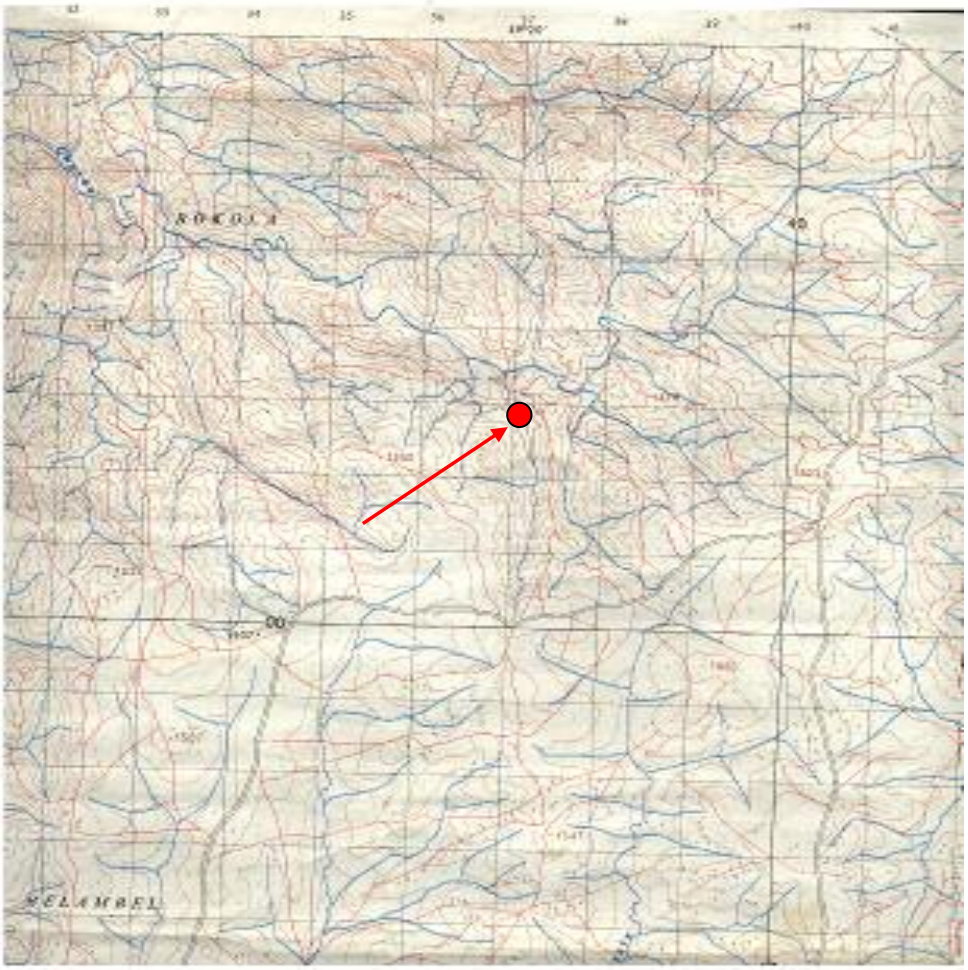
6- BOKOLA

6-1 Location

The site located by North West of Negele and it accessible by 4Km long dry weather access road from the HareKelo-Jidola gravel road. The selected water intervention site is far 57Km from Negele towards Northwest. In UTM geographic coordinate system the place where the well located appears at:

Zone	37N
North	602800m
East	537207m

Location Map of Bokola
Adapted from 1:50,000 topographic map
Of Bitata sheet
Sheet no 0539C2



6-2 Well excavation

Well excavation work started in December 2002 and completed on January25, 2002. The diameter of the well was 2.2m, and the final depth of the well is 5.2m. Water stroke at the depth of 2.6m and the static water level inside the well is 2.5m below ground level. The main aquifer of the well is fractured biotite gneiss, and the excavation work at Bokola finalized with out and drilling trouble.

6-3 casing

Blind as well as slotted concrete ring casings were lowered in to the well according to the following order from the ground level:

Blind 0 up to 2.2m
Screen (slotted rings) 2.2m up to end depth i.e. 5.2m.

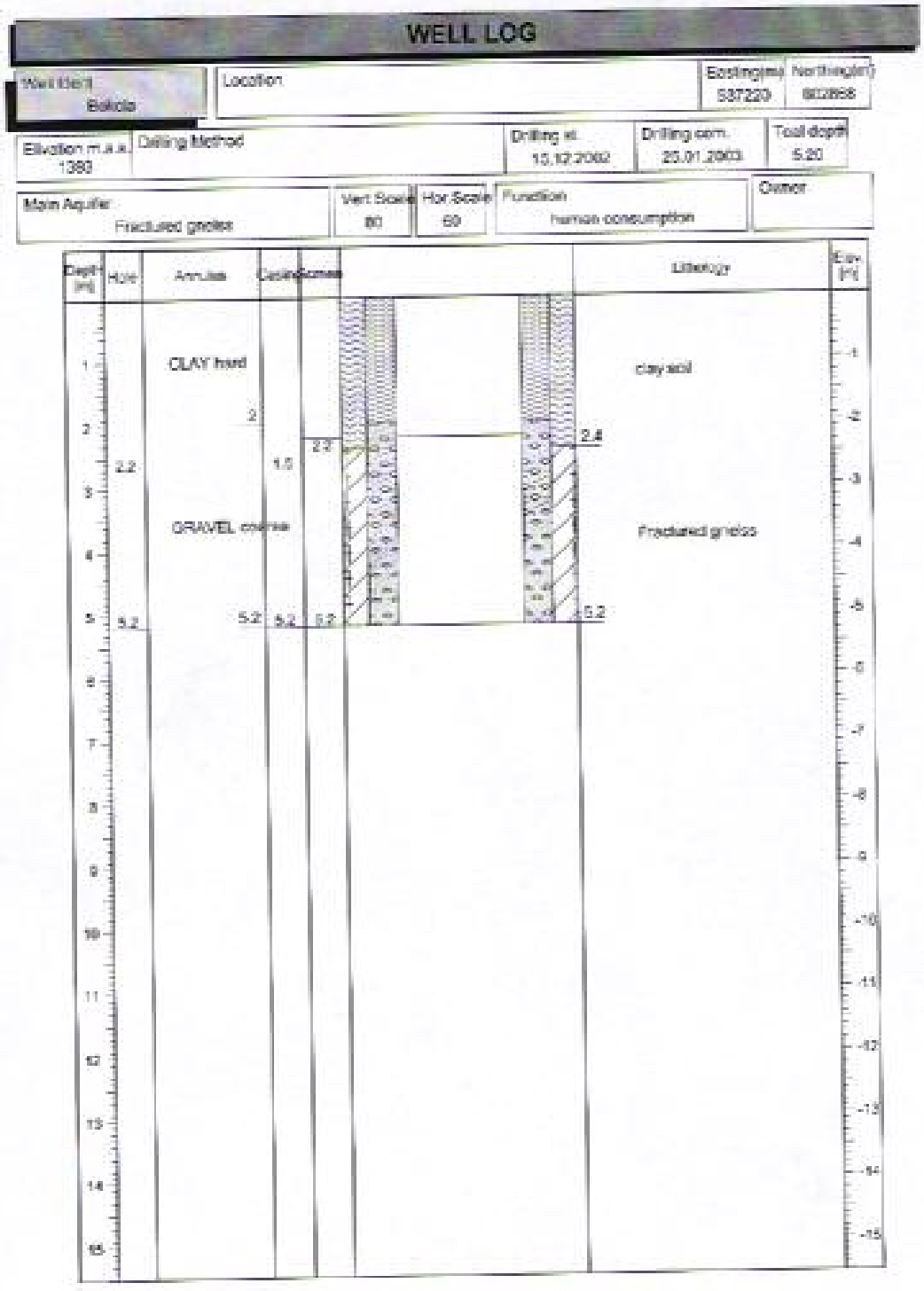
The ring is further rise 0.60m above ground level to prevent flooding and to permit the well head structure. The diameter of the rings is same for all and it is 1.5 in the internal part and 1.7m in the outer part.

6-4 Packing

The well annular space packed by selected river gravel from the depth of 2m up to the bottom of the hole to facilitate the in flow of water into the well and to server as filtering media. The rest part of the well was packed by clay in order to prevent the percolation of surface water in to the well.

6-5 Well log

Samples were continuously observed in order to identify the lithological layering and the samples were used to set the well log. The well lithological log and the well casing as well as packing design are shown on the following chart.


WELL LOG
Well Identif.
Bokolo
Location
Easting(m)
537220
Northing(m)
802868
Elivation m.a.s.l.
1389
Drilling Method
Drilling st.
15.12.2002
Drilling com.
25.01.2003
Total depth
5.20
Main Aquifer
Fractured gneiss
Vert Scale
80
Hor Scale
69
Function
human consumption
Owner
Depth [m]
Hole
Annulus
Casing
Screen
Litology
Elev. [m]
CLAY hard
clay soil
GRAVEL coarse
Fractured gneiss
2.2
2
1.0
2.3
2.4
5.2
5.2
5.2
5.2

6-6 Pumping test

Constant discharge test was adapted for the well test. The test carried out for total of 450 minutes including the recovery test, and the data obtained from the test used in Cooper and Jacob equations to calculate transimisivity. Theis and Cooper method applied for the recovery test. The general information regarding the test is presented below and the results obtained are presented in the next consecutive pages.

Date of test 16/04/2003	Constant Discharge Test
Location: Zone Borena	SWL 3.1
District Liben	Ref.Point 0.60m A.G.L
Kebele Bokola	Q(m^3/day) 64.55

6-7 Water quality

Water sample had taken in the end period of the pumping test. The sample also tested for some drinking water quality parameters and the result obtained from the test listed below.

Conductivity	1064 µs/cm
Temperature	23.5^0c
Total Hardness	Medium Hard
Chloride Cl-	50mg/lit
Ph	7
Ammonium	nill
Nitrite	0.25
Sulphate	<200ppm

6-8 Well head and fencing

The well head constructed on the well is the usual COOPI standard well head i.e. 4m*4m with concrete slab on top. First the structure rise from the ground to sufficient height (average=0.60m) by masonry and on top covered by reinforced concrete slab with manhole and inlet hole for both hand pump.

After the well head construction INDIAN MARK II hand pump installed, and finally the well site fenced by barbed wire with support of angle iron.

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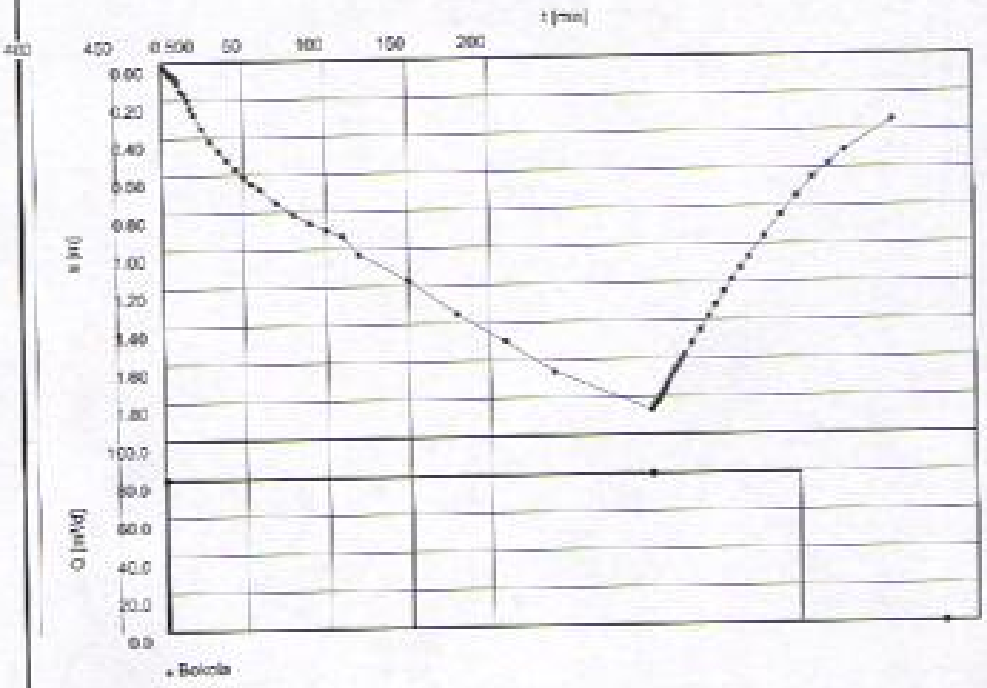
Pumping test analysis
Time-Drawdown plot
with discharge

Date: 17.04.2003 | Page: 1
Project: USAID
Evaluated by: Gebachew A.

Pumping Test No: 1
Test conducted on: 16/4/03
Bokelo
Discharge: 64.09 m³/d

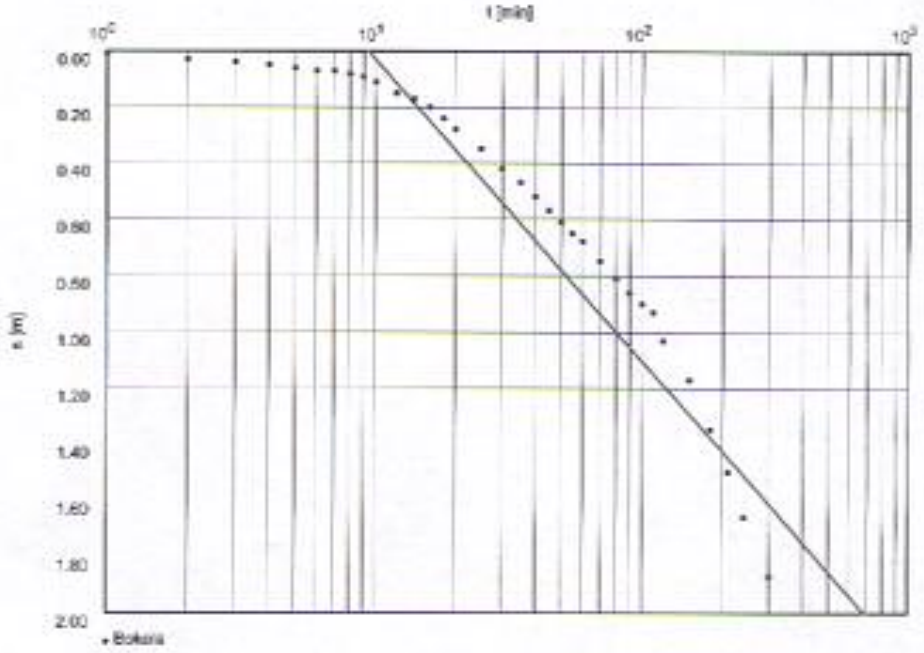


Waterloo Hydrogeologic 160 Columbia St. W.	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 17.04.2003	Page: 1
		Project: USAID	
		Evaluated by: Gelechwa A.	

Pumping Test No. 1 — Test conducted on: 16/4/03

Bokola

Discharge 64.80 m³/d



Transmissivity [m²/min]: 7.85×10^{-3}

Storativity: 2.86×10^{-7}

Waterloo Hydrogeologic
180 Columbia St. W.

Pumping test analysis
Recovery method after
THEIS & JACOB
Confined aquifer

Date: 17.04.2008 | Page: 1

Project: USAID

Evaluated by: Getachew A.

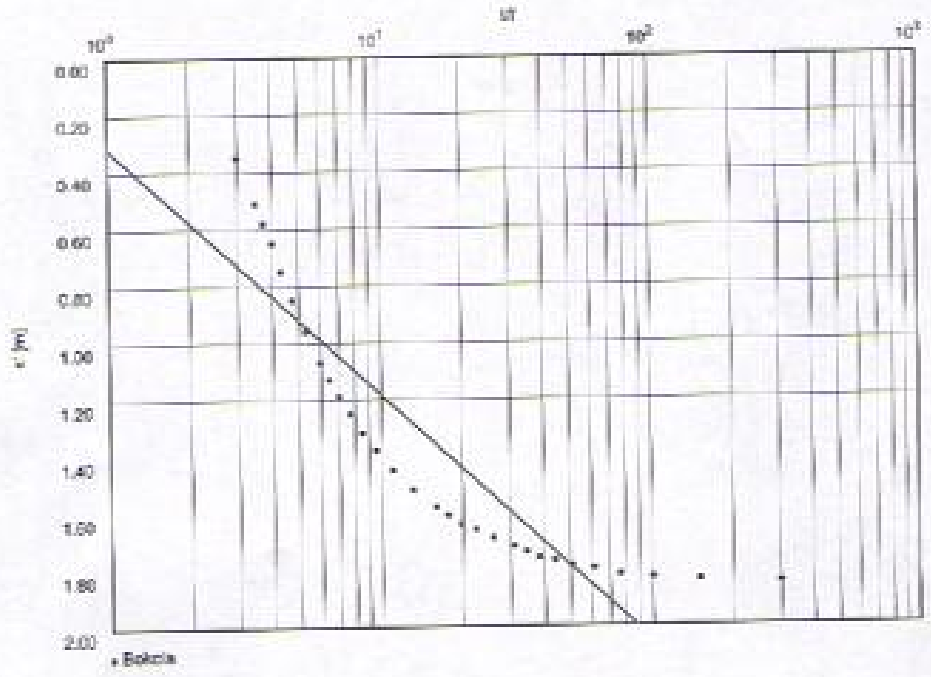
Pumping Test No: 1

Test conducted on: 16/4/08

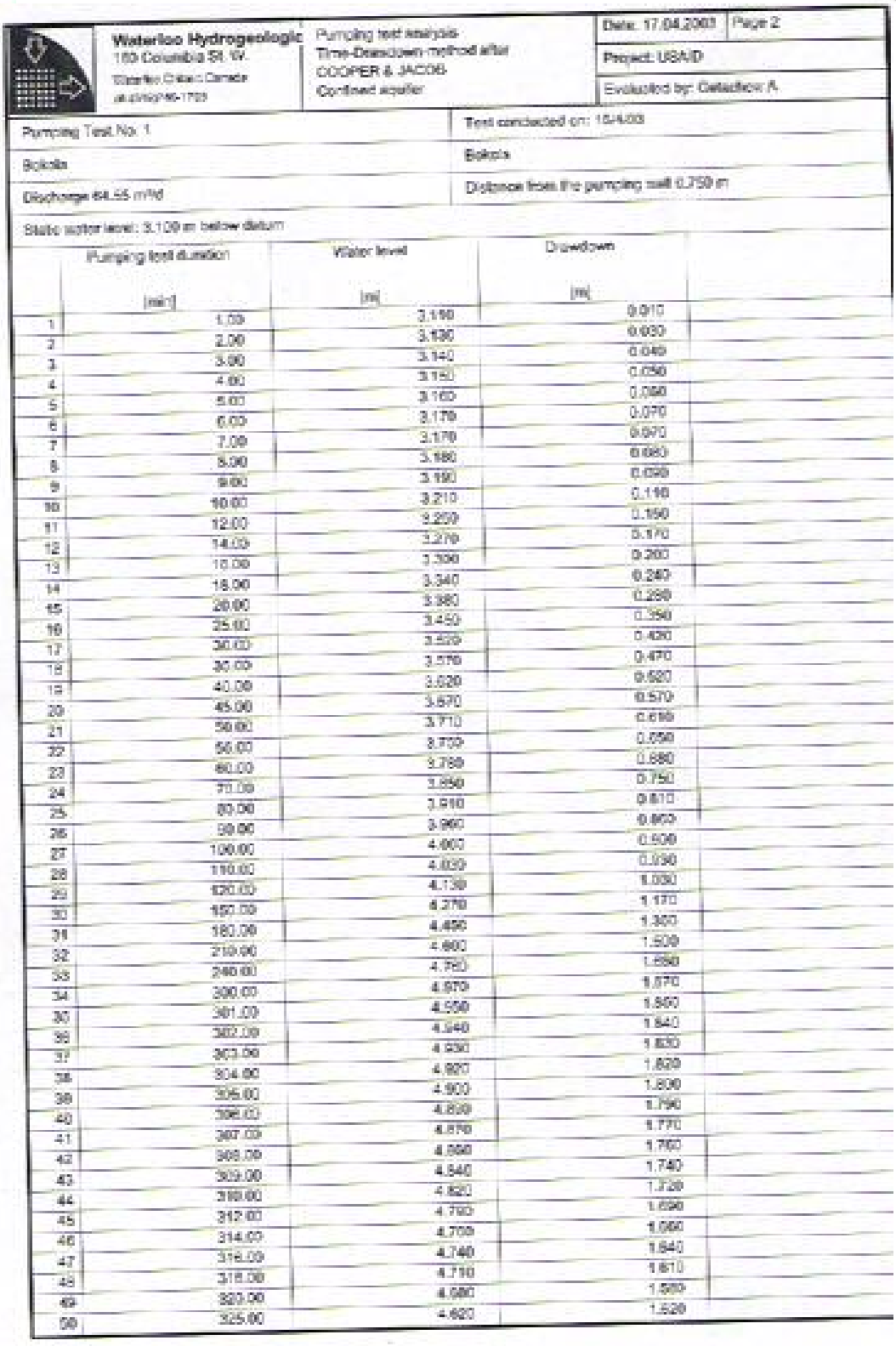
Bokola

Discharge 64.55 m³/d

Pumping test duration: 300:00 min



Transmissivity [m²/min]: 0.46 x 10^{-2}



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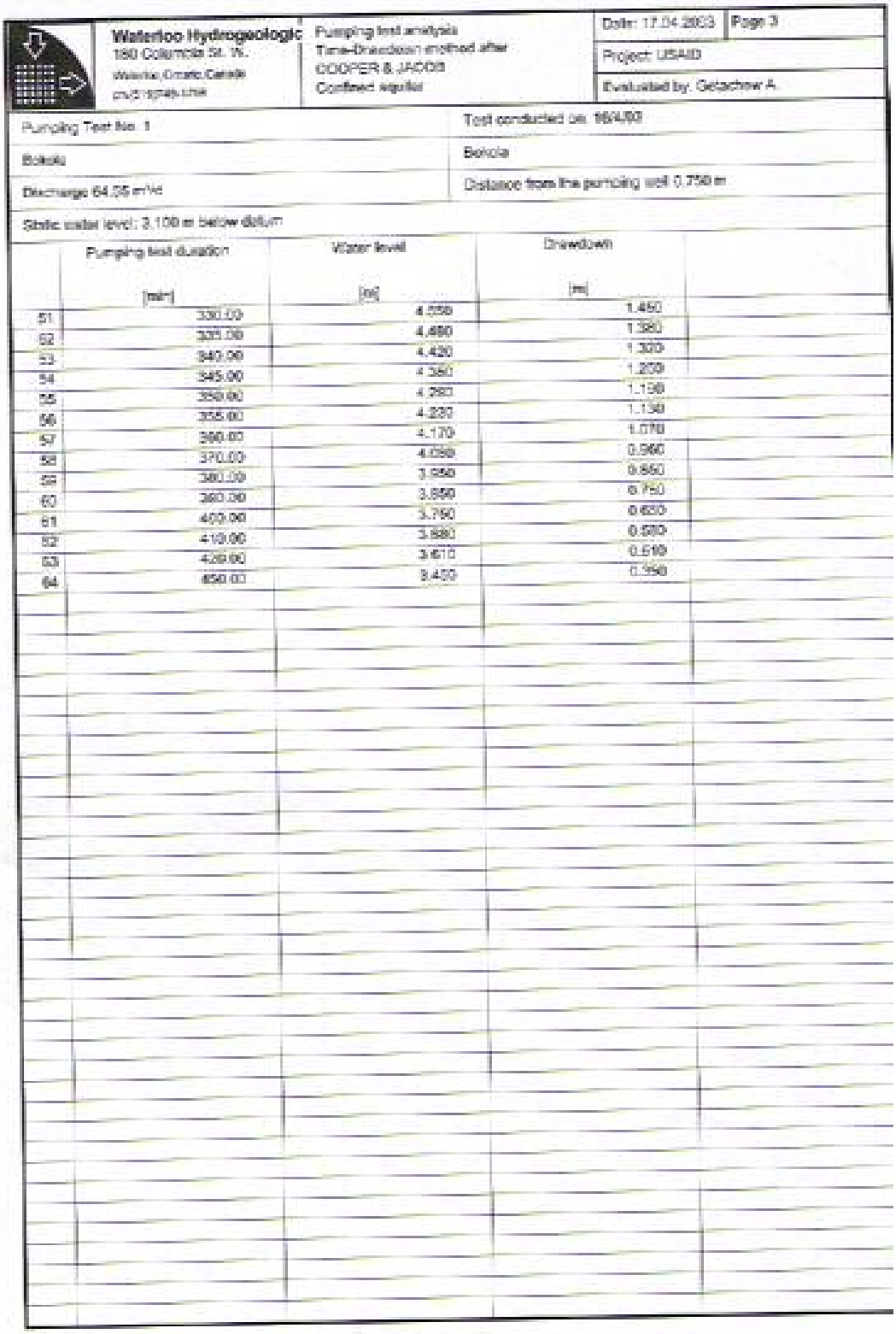
Pumping test analysis
Time-Drawdown method after
COOPER & JACOB
Confined aquifer

Date: 17.04.2003 | Page 2
Project: USAID
Evaluated by: Getachew A.

Pumping Test No: 1
Test conducted on: 15/4/03
Bokolla
Bokolla
Discharge 64.55 m³/d
Distance from the pumping well: 0.759 m
Static water level: 3.129 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]
1	1.00	3.139	0.010
2	2.00	3.139	0.010
3	3.00	3.140	0.011
4	4.00	3.140	0.011
5	5.00	3.140	0.011
6	6.00	3.139	0.010
7	7.00	3.139	0.010
8	8.00	3.139	0.010
9	9.00	3.139	0.010
10	10.00	3.210	0.081
11	12.00	3.209	0.080
12	14.00	3.279	0.150
13	16.00	3.339	0.210
14	18.00	3.340	0.211
15	20.00	3.389	0.260
16	25.00	3.459	0.330
17	30.00	3.509	0.380
18	35.00	3.559	0.430
19	40.00	3.609	0.480
20	45.00	3.659	0.530
21	50.00	3.710	0.581
22	55.00	3.759	0.630
23	60.00	3.789	0.660
24	70.00	3.859	0.730
25	80.00	3.910	0.781
26	90.00	3.960	0.831
27	100.00	4.000	0.871
28	110.00	4.039	0.910
29	120.00	4.139	1.010
30	130.00	4.279	1.150
31	140.00	4.429	1.300
32	150.00	4.489	1.360
33	160.00	4.660	1.531
34	170.00	4.750	1.621
35	180.00	4.809	1.680
36	190.00	4.859	1.730
37	200.00	4.899	1.770
38	210.00	4.940	1.811
39	220.00	4.980	1.851
40	230.00	5.020	1.891
41	240.00	5.060	1.931
42	250.00	5.100	1.971
43	260.00	5.140	2.011
44	270.00	5.180	2.051
45	280.00	5.220	2.091
46	290.00	5.260	2.131
47	300.00	5.300	2.171
48	310.00	5.340	2.211
49	320.00	5.380	2.251
50	325.00	5.420	2.291



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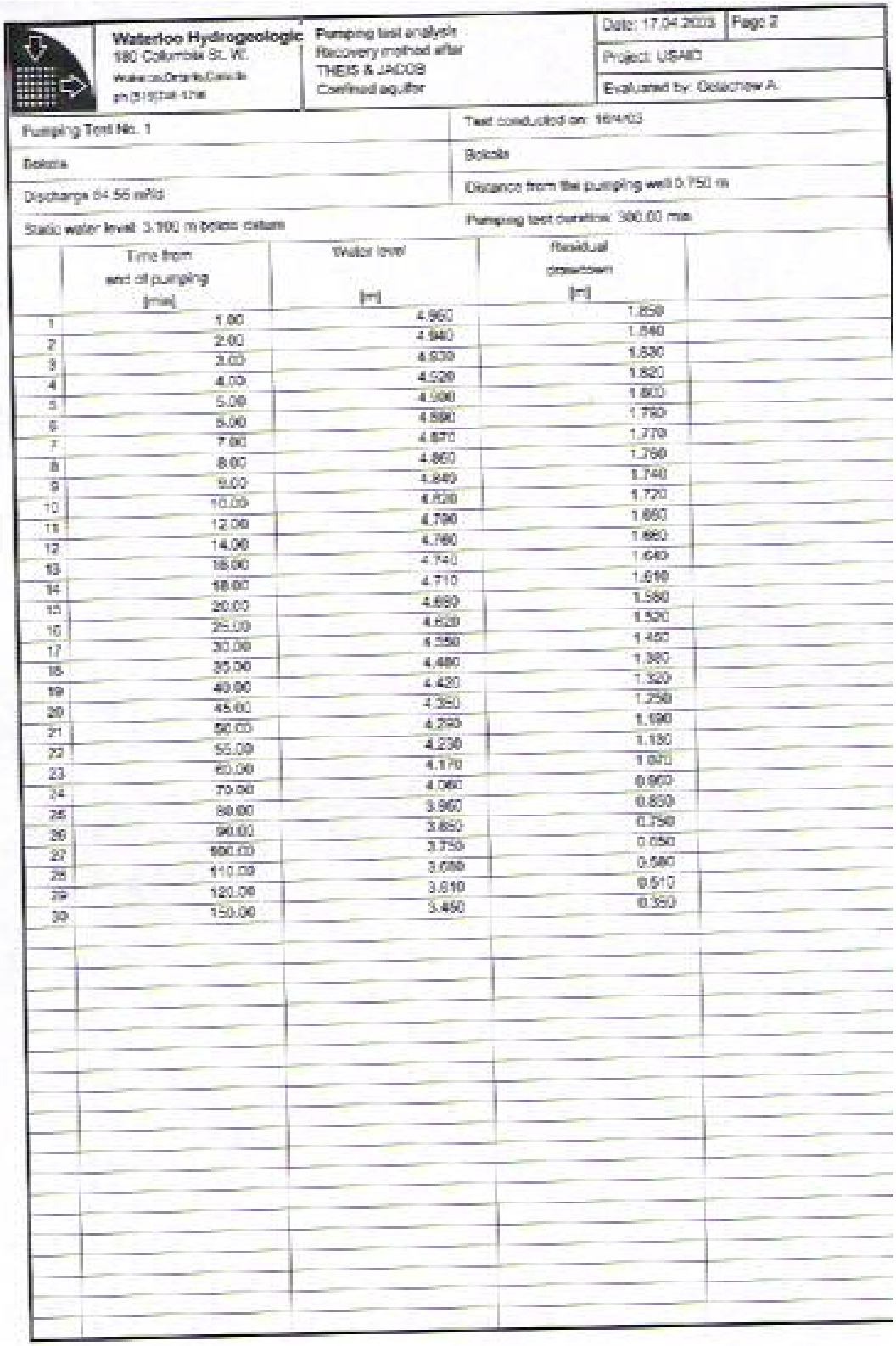
Pumping test analysis
Time-Drawdown method after
COOPER & JACOB
Confined aquifer

Date: 17.04.2003 | Page 3
Project: USAID
Evaluated by: Getachew A.

Pumping Test No. 1 — Test conducted on: 16/4/03
Boloklu — Bekola
Discharge 64.05 m³/d — Distance from the pumping well: 0.750 m
Static water level: 3.100 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]
51	330.00	4.550	1.450
52	335.00	4.480	1.380
53	340.00	4.420	1.320
54	345.00	4.380	1.209
55	350.00	4.280	1..180
56	355.00	4.230	1..130
57	360.00	4..170	1.070
58	370.00	4.050	0.960
59	380.00	3.950	0.850
60	390.00	3.850	0.750
61	400.00	3.750	0.620
62	410.00	3.680	0.580
63	420.00	3.610	0.510
64	850.00	3.450	0.350



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Pumping test analysis
Recovery method after
THEIS & JACOB
Confined aquifer

Date: 17.04.2023 | Page: 2
Project: USAID
Evaluated by: Gelachew A.

Pumping Test No. 1
Test conducted on: 16/4/23
Bokola
Bokola
Discharge 84.56 m³/d
Distance from the pumping well 0.750 m
Static water level 3.160 m below datum
Pumping test duration 360.00 min

	Time from end of pumping [min]	Water level [m]	Residual drawdown [m]
1	1.00	4.960	1.800
2	2.00	4.940	1.840
3	3.00	4.930	1.830
4	4.00	4.920	1.820
5	5.00	4.900	1.800
6	6.00	4.880	1.760
7	7.00	4.870	1.770
8	8.00	4.860	1.760
9	9.00	4.840	1.740
10	10.00	4.820	1.720
11	12.00	4.790	1.690
12	14.00	4.780	1.680
13	16.00	4.740	1.640
14	18.00	4.710	1.610
15	20.00	4.690	1.590
16	25.00	4.620	1.520
17	30.00	4.550	1.450
18	35.00	4.480	1.380
19	40.00	4.420	1.320
20	45.00	4.360	1.260
21	50.00	4.290	1.190
22	55.00	4.230	1.130
23	60.00	4.170	1.070
24	70.00	4.060	0.960
25	80.00	3.960	0.850
26	90.00	3.850	0.750
27	100.00	3.750	0.650
28	110.00	3.680	0.580
29	120.00	3.610	0.510
30	150.00	3.450	0.350

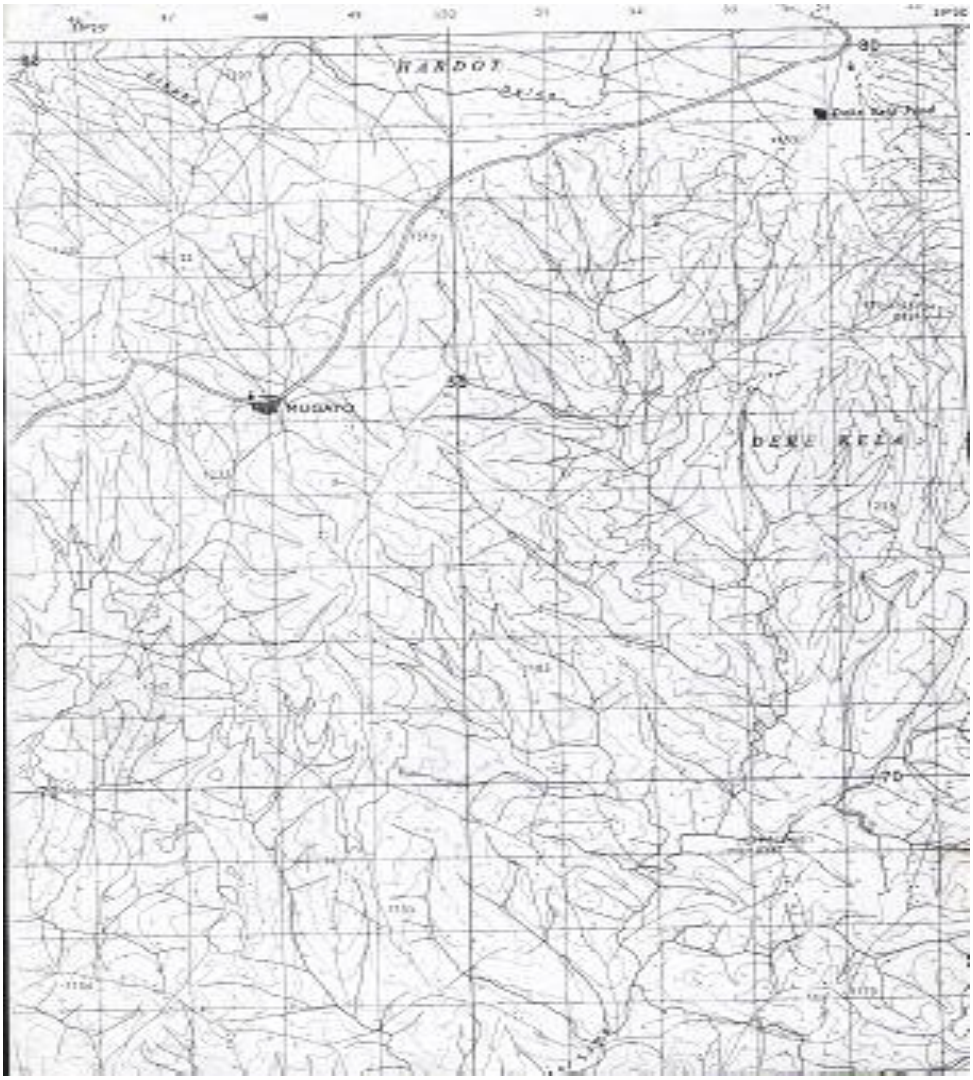
7- Tula Dhelan

7-1 Location

The site located by West of Negele and it accessible dry weather road from Negele. The selected water intervention site is far 24Km from Negele towards west. In UTM geographic coordinate system the place where the well located appears at:

Zone 37N
North 581204m
East 548869m

Location Map of Tula Dhelan
Adapted from 1:50,000 topographic map
Of Mugayo sheet
Sheet no 0539C4



7-2 Well excavation

First the excavated up to the depth of 6.2m meter, but due to fast collapsing the hole abandoned and another place in near by selected for excavation of alternative hole. Well excavation work at the second site started in June, 2002 and completed on June27, 2002. The diameter of the well was 2.2m, and the final depth of the well is 7.3m. Water stroke at the depth of 5.2m and the static water level inside the well is 4.68m below ground level. The main aquifer of the well is sand.

7-3 casing

Blind as well as slotted concrete ring casings were lowered in to the well according to the following order from the ground level:

Blind 0 up to 4.3m, external diameter of 1.7m
Screen (slotted rings) 4.3m up to 5.3m, external diameter of 1.7m
Screen (slotted rings) from 5.3 up to end depth i.e. 7.3m. External diameter of 1.5m

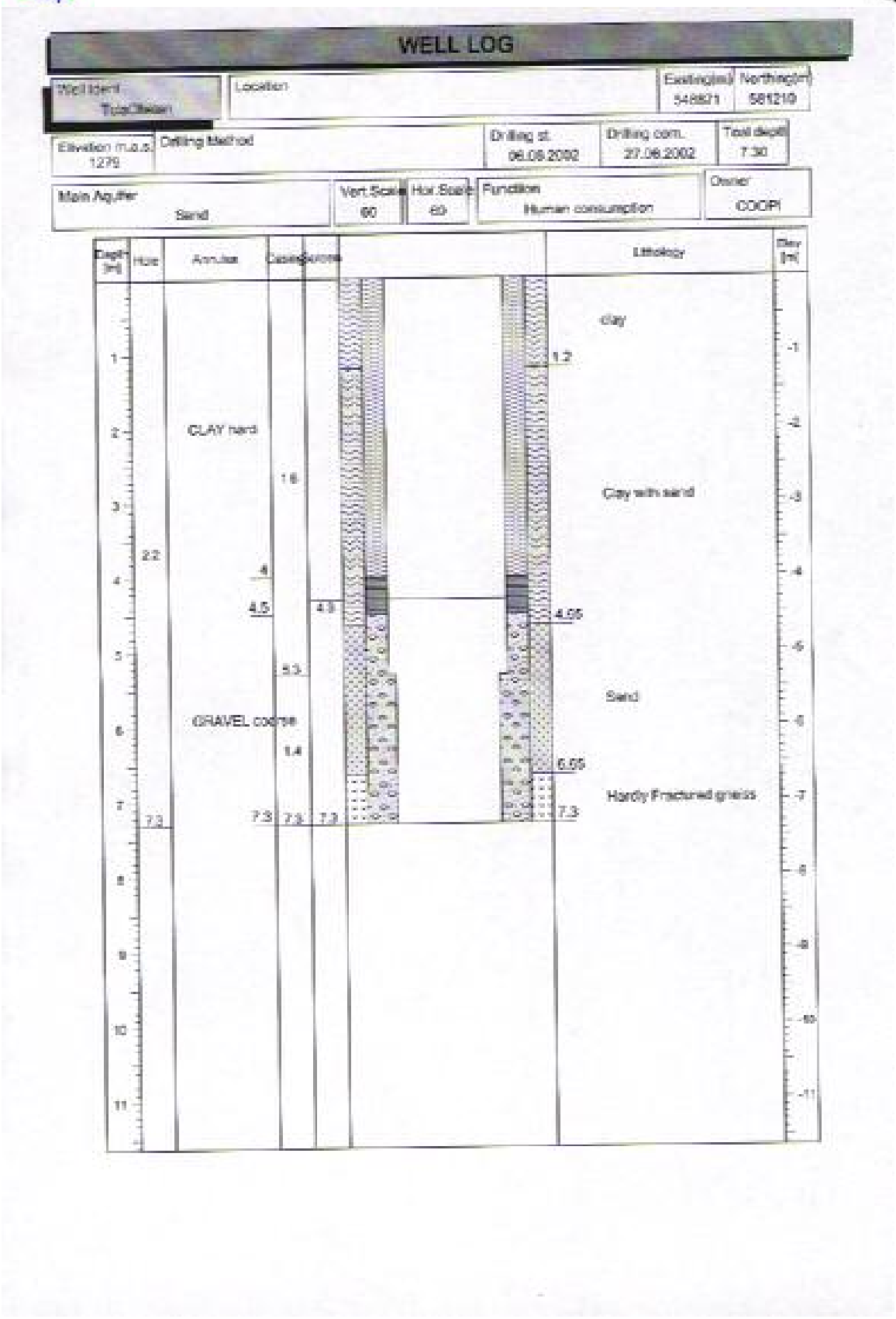
The ring is further rise 0.60m above ground level to prevent flooding and to permit the well head structure.

7-4 Packing

The well annular space packed by selected river gravel from the depth of 4m up to the bottom of the hole to facilitate the in flow of water into the well and to server as filtering media. The rest part of the well was packed by clay in order to prevent the percolation of surface water in to the well.

7-5 Well log

Samples were continuously observed in order to identify the lithological layering, and the samples are used to set the well log. The well lithological log and the well casing as well as packing design are shown on the following chart.


WELL LOG
Location
Easting(m)
548871
Northing(m)
581219
Elevation m.a.s.l.
1279
Drilling Method
Drilling st.
06.06.2002
Drilling com.
27.06.2002
Total depth
7.30
Main Aquifer
Sand
Vert.Scale
60
Hor.Scale
60
Function
Human consumption
Owner
COOPI
Depth [m]
Hole
Annular
Casing/Screen
Lithology
Elev [m]
clay
CLAY hard
Clay with sand
Sand
GRAVEL coarse
Hardly Fractured gneiss
1.2
2.2
1.6
4
4.5
4.9
4.95
5.3
1.4
6.05
7.3
7.3
7.3
7.3
7.3

7-6 Pumping test

Constant discharge test was adapted for the well test. The test carried out for total of 420 minutes including the recovery test, and the data obtained from the test is used in Cooper and Jacob equations to calculate transimisivity. Theis and Cooper method applied for the recovery test. The general information regarding the test is presented below and the results obtained are presented in the next consecutive pages.

Date of test 23/09/2002	Constant Discharge Test
Location: Zone Borena	SWL 5.28m
District Liben	Ref.Point 0.60m A.G.L
Kebele Hardot	Q(lit/sec) 0.65

7-7 Water quality

Water sample had taken in the end period of the pumping test. The sample also tested for some drinking water quality parameters and the result obtained from the test listed below.

Conductivity	764 µs/cm
Temperature	25.1^0c
Total Hardness	Medium Hard
Chloride Cl-	50mg/lit
Ph	7.5
Ammonium	nill
Nitrite	nill
Sulphate	<200ppm

7-8 Well head and fencing

The well head constructed on the well is the usual COOPI standard well head i.e. 4m*4m with concrete slab on top. First the structure rise from the ground to sufficient height (average=0.60m) by masonry and on top covered by reinforced concrete slab with manhole and inlet hole for both hand pump.

After the well head construction INDIAN MARK II hand pump installed, and finally the well site fenced by barbed wire with support of angle iron.

Waterloo Hydrogeologic
180 Columbia St. W.

Pumping test analysis
Time-Drawdown plot

Date: 24.09.2002 | Page 1

Project: USAID-OFDA

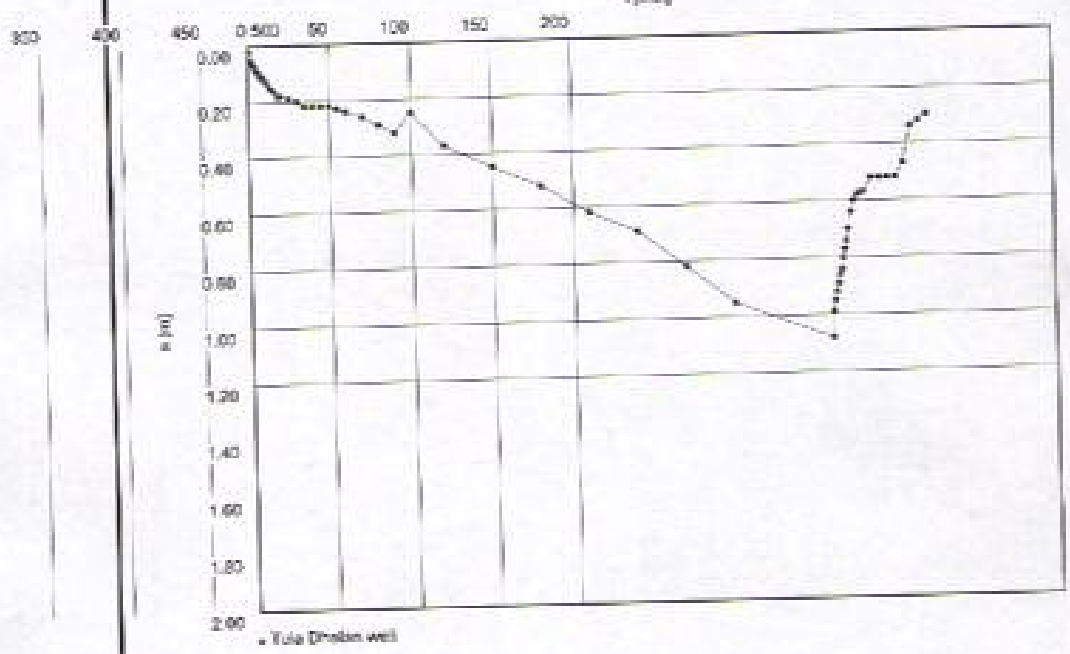
Evaluated by: Gotychew Akilic

Pumping Test No: 1

Test conducted on: 23.09.2002

Tulo Dhelan

Discharge: 0.65 l/s



Waterloo Hydrogeologic
160 Columbia St. W.

Pumping test analysis
Time-Drawdown method after
COOPER & JACOB
Confined aquifer

Date: 24.09.2002 | Page 1

Project: USAID-OFDA

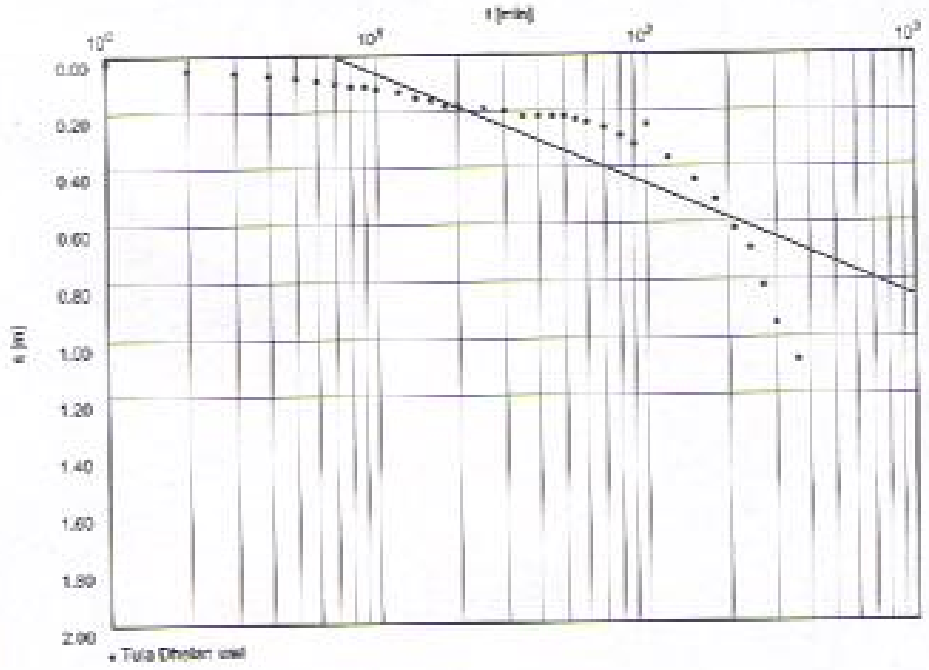
Evaluated by: Getachew Alelo

Pumping Test No. 1

Test conducted on: 23.09.2002

Tulo Dheloo

Discharge 0.55 l/s



Tulo Dheloo well

Transmissivity [m²/min]: 1.80 x 10⁻²

Storativity: 4.90 x 10⁻⁵

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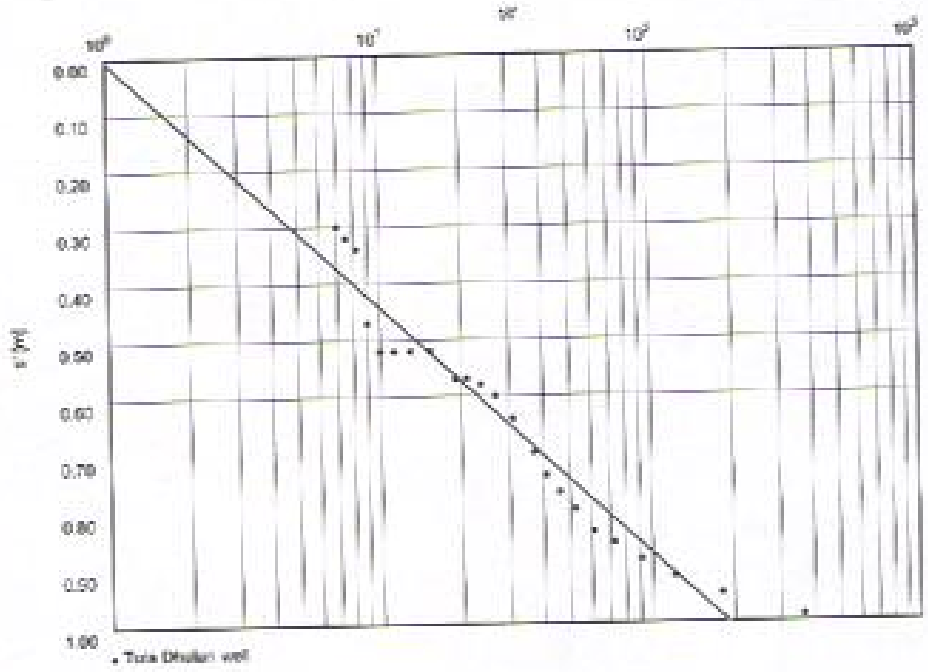
Pumping test analysis
Recovery method: other
THEIS & JACOB
Confined aquifer

Date: 24.09.2002 | Page: 1
Project: USAID-OFDA
Evaluated by: Gelichew Alefe

Pumping Test No: 1
Test conducted on: 23.09.2002
Tula Dhelan
Discharge: 0.55 l/s
Pumping test duration: 360.00 min



Transmissivity [m²/day]: 1.83 x 10⁻²

Waterloo Hydrogeologic | Pumping test analysis: Time-Drawdown plot | Date: 24.03.2003 | Page 2

150 Columbia St. W. | Project: USAID-CFDA

Evaluated by: Getachew Alofe

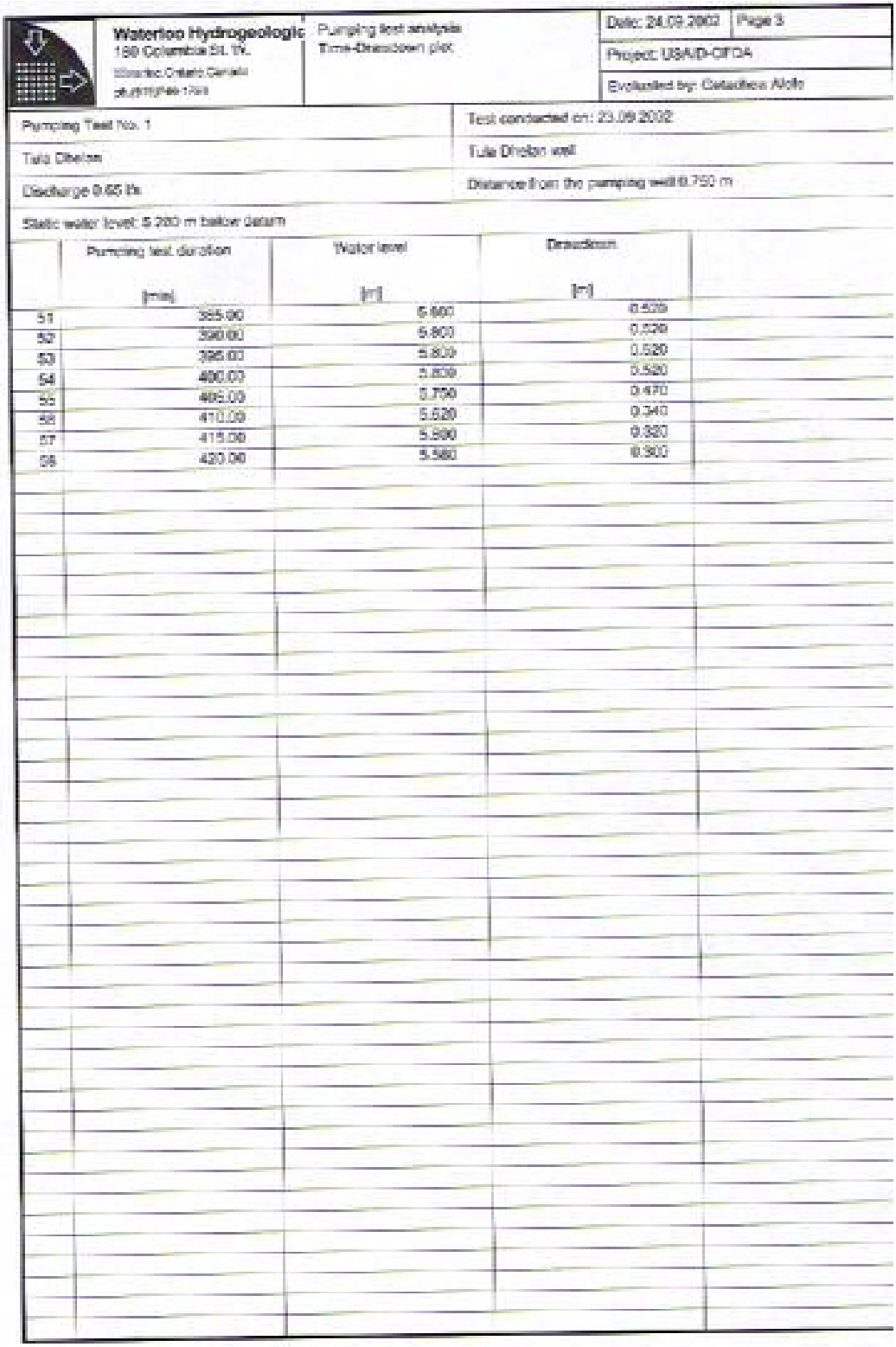
Pumping Test No. 1 | Test conducted on: 23.09.2002

Tulu Dhelon | Tulu Dhelon well

Discharge 0.62 l/s | Distance from the pumping well 0.750 m

Static water level: 5.260 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]
1	1.00	5.300	0.020
2	2.00	5.330	0.050
3	3.00	5.340	0.060
4	4.00	5.350	0.070
5	5.00	5.360	0.080
6	6.00	5.370	0.090
7	7.00	5.380	0.100
8	8.00	5.390	0.110
9	9.00	5.398	0.118
10	10.00	5.400	0.120
11	12.00	5.410	0.130
12	14.00	5.420	0.130
13	16.00	5.440	0.180
14	18.00	5.450	0.190
15	20.00	5.460	0.200
16	22.00	5.470	0.210
17	30.00	5.480	0.220
18	35.00	5.500	0.240
19	40.00	5.500	0.240
20	45.00	5.500	0.240
21	50.00	5.500	0.240
22	55.00	5.510	0.250
23	60.00	5.520	0.260
24	70.00	5.540	0.280
25	80.00	5.570	0.310
26	90.00	5.580	0.320
27	100.00	5.590	0.330
28	120.00	5.600	0.340
29	150.00	5.730	0.470
30	180.00	5.800	0.540
31	210.00	5.880	0.620
32	240.00	5.970	0.710
33	270.00	6.100	0.840
34	300.00	6.230	0.970
35	330.00	6.300	1.040
36	361.00	6.270	0.960
37	362.00	6.250	0.990
38	363.00	6.280	0.920
39	364.00	6.170	0.910
40	365.00	6.140	0.880
41	366.00	6.120	0.860
42	367.00	6.090	0.830
43	368.00	6.060	0.800
44	369.00	6.030	0.770
45	370.00	5.980	0.740
46	372.00	5.960	0.700
47	374.00	5.880	0.640
48	376.00	5.800	0.560
49	378.00	5.850	0.570
50	380.00	5.850	0.570



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Pumping test analysis
Time-Drawdown plot

Date: 24.09.2002 | Page 3
Project: USAID-OFDA
Evaluated by: Getaddress Alofe

Pumping Test No. 1
Test conducted on: 23.09.2002

Tula Dhelon
Tula Dhelon well

Discharge 0.65 l/s
Distance from the pumping well 0.750 m

Static water level: 5.200 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]
51	395.00	5.660	0.460
52	390.00	5.800	0.600
53	395.00	5.800	0.600
54	400.00	5.800	0.600
55	405.00	5.750	0.470
56	410.00	5.620	0.340
57	415.00	5.580	0.320
58	420.00	5.580	0.300

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Pumping test analysis
Recovery method after
THEIS & JACOB
Confined aquifer

Date: 24.05.2002 | Page 2

Project: USAID-OFDA

Evaluated by: Getachew Alefe

Pumping Test No: 1

Test conducted on: 23.05.2002

Tulo Dhelan

Tulo Dhelan well

Discharge 0.65 l/s

Distance from the pumping well: 0.750 m

Static water level: 5.290 m below datum

Pumping test duration: 360.00 min

	Time from end of pumping [min]	Water level [m]	Residual drawdown [m]
1	1.00	6.270	0.980
2	2.00	6.230	0.950
3	3.00	6.210	0.920
4	4.00	6.170	0.890
5	5.00	6.140	0.860
6	6.00	6.120	0.840
7	7.00	6.080	0.800
8	8.00	6.060	0.770
9	9.00	6.040	0.740
10	10.00	5.960	0.709
11	12.00	5.900	0.649
12	14.00	5.880	0.609
13	16.00	5.860	0.580
14	18.00	5.850	0.570
15	20.00	5.850	0.570
16	25.00	5.830	0.550
17	30.00	5.830	0.520
18	35.00	5.830	0.522
19	40.00	5.830	0.520
20	45.00	5.750	0.470
21	50.00	5.690	0.349
22	55.00	5.800	0.329
23	59.00	5.590	0.309

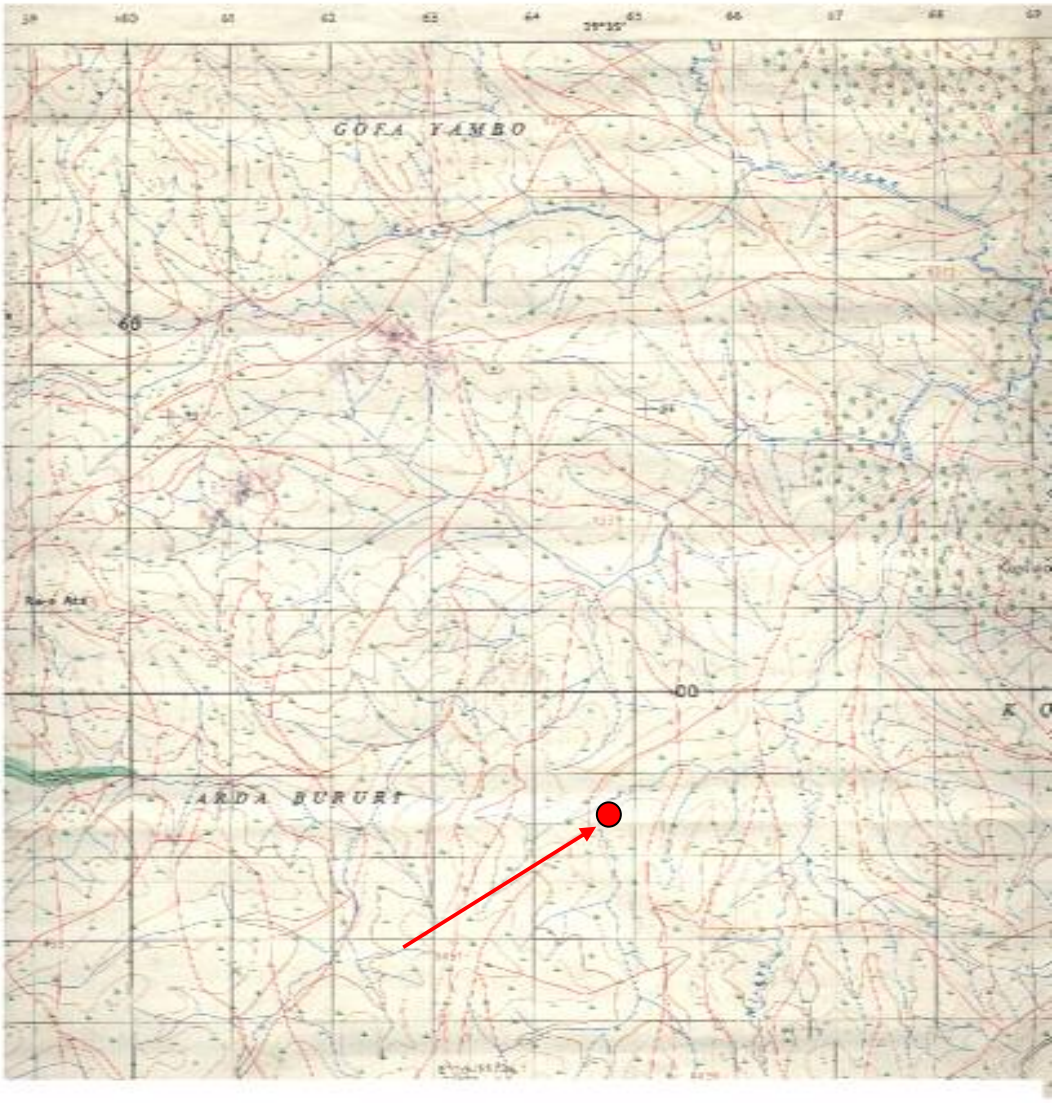
8- Arda Bururi

8-1 Location

The site located by North of Negele and it is accessible by 9Km long dry weather access road from Negele. In UTM geographic coordinate system the place where the well located appears at:

Zone 37N
East 564880m
North 597507m

Location Map of Arda Bururi
Adapted from 1:50,000 topographic map
Of Negele Borena sheet
Sheet no 0539 D1



8-2 Well excavation

Well excavation work started in February 2003 and completed on February25, 2003. The diameter of the well was 2.2m, and the final depth of the well is 8m. Water stroke at the depth of 5.5m and the static water level inside the well is 5.42m below ground level. The main aquifer of the well is sand.

8-3 casing

Blind as well as slotted concrete ring casings were lowered in to the well according to the following order from the ground level:

Blind 0 up to 3m
Screen (slotted rings) 3m up to end depth of the well i.e. 8m.

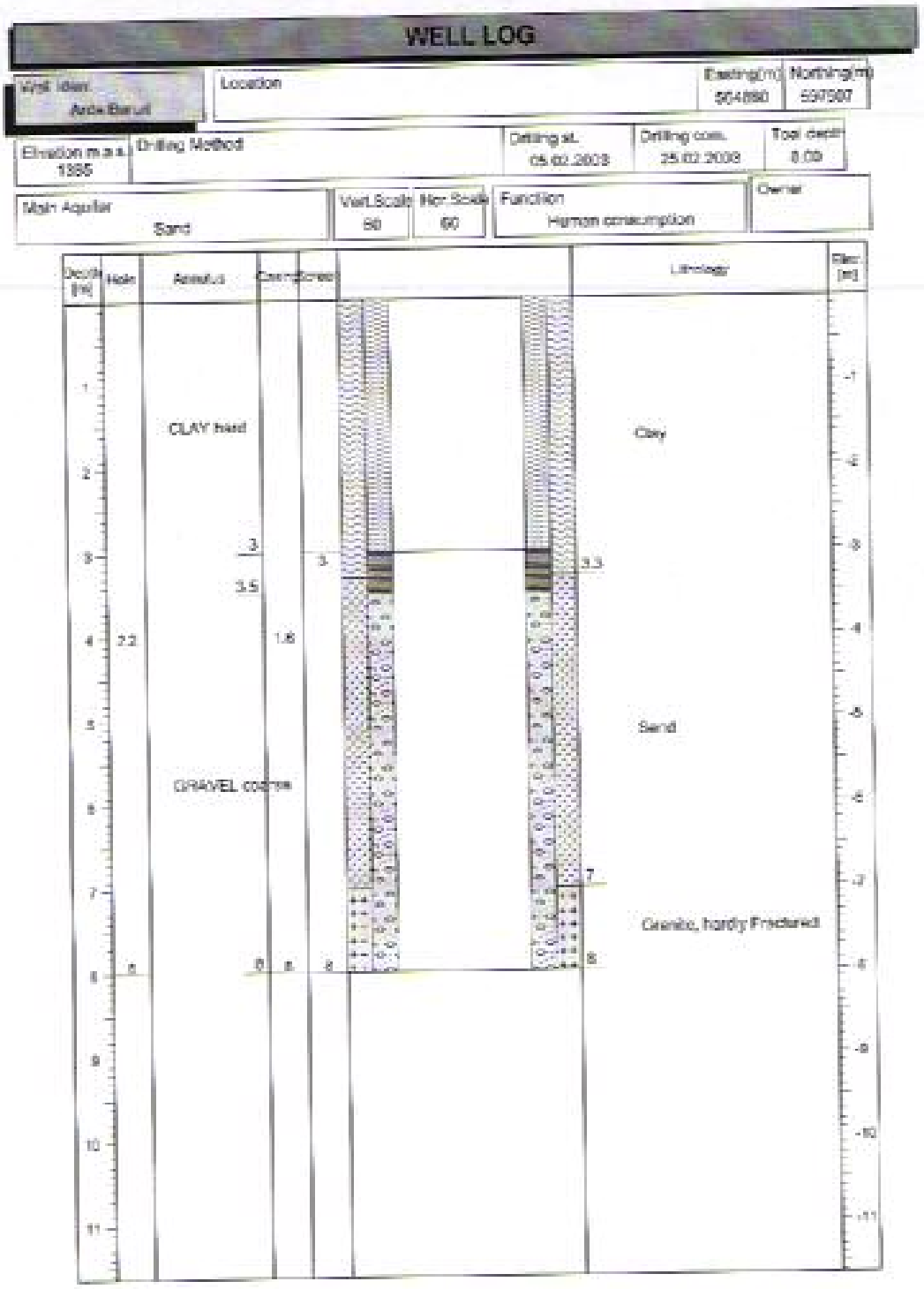
The ring is further rise 0.60m above ground level to prevent flooding and to permit the well head structure. The diameter of the rings is same for all and it is 1.5 in the internal part and 1.7m in the outer part.

8-4 Packing

The well annular space packed by selected river gravel from the depth of 3.5m up to the bottom of the hole to facilitate the in flow of water into the well and to server as filtering media. The rest part of the well was packed by clay and cement in order to prevent the percolation of surface water in to the well.

8-5 Well log

Samples were continuously observed in order to identify the lithological layering and the samples were used to set the well log. The well lithological log and the well casing as well as packing design are shown on the following chart.


WELL LOG
Location
Easting(m)
504880
Northing(m)
597587
Elevation m.a.s.l.
1385
Drilling Method
Drilling st.
05.02.2008
Drilling com.
25.02.2008
Main Aquifer
Sand
Vert.Scale
50
Hor. Scale
60
Function
Human consumption
Owner
Depth [m]
Hole
Annulus
Casing
Screen
Lithology
Filter [m]
CLAY hard
Clay
Sand
Ceramic, hardly Fractured
3
3.5
2.2
1.6
3.3
7
8

8-6 Pumping test

Constant discharge test was adapted for the well test. The test carried out for total of 420 minutes including the recovery test, and the data obtained from the test is used in Cooper and Jacob equations to calculate transimisivity. Theis and Cooper method applied for the recovery test. The general information regarding the test is presented below and the results obtained from the analisis are presented in the next consecutive pages.

Date of test 07/05/2003	Constant Dicharge Test
Location: Zone Borena	SWL 6.02m
District Liben	Ref.Point 0.60m A.G.L
Kebele ArdaBururi	Q(lit/sec) 1.00

8-7 Water quality

Water sample had taken in the end period of the pumping test. The sample also tested for some drinking water quality parameters and the result obtained from the test listed below.

Conductivity	1917 µs/cm
Temperature	24.9^0c
Total Hardness	445ppm, Hard
Chloride Cl-	50mg/lit
Ph	7.25
Ammonium	nill
Nitrite	nill
Sulphate	<200ppm

8-8 Well head and fencing

The well head constructed on the well is the usual COOPI standard well head i.e. 4m*4m with concrete slab on top. First the structure rise from the ground to sufficient height (average=0.60m) by masonry and on top covered by reinforced concrete slab with manhole and inlet hole for both hand pump.

After the well head construction INDIAN MARK II hand pump installed, and finally the well site fenced by barbed wire with support of angle iron.

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Pumping test analysis
Time-Drawdown plot

Project: USAID-OFDA

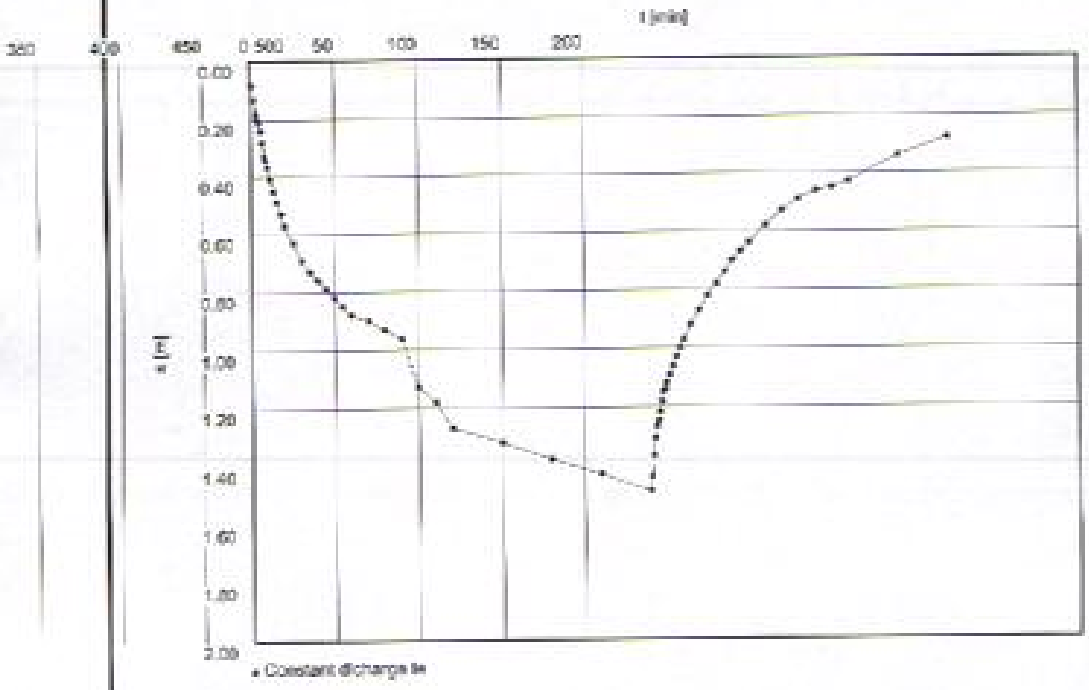
Evaluated by: Getachew Alofi

Pumping Test No: 1

Test conducted on: 07.05.2009

Arda Bunari

Discharge: 1.00 l/s



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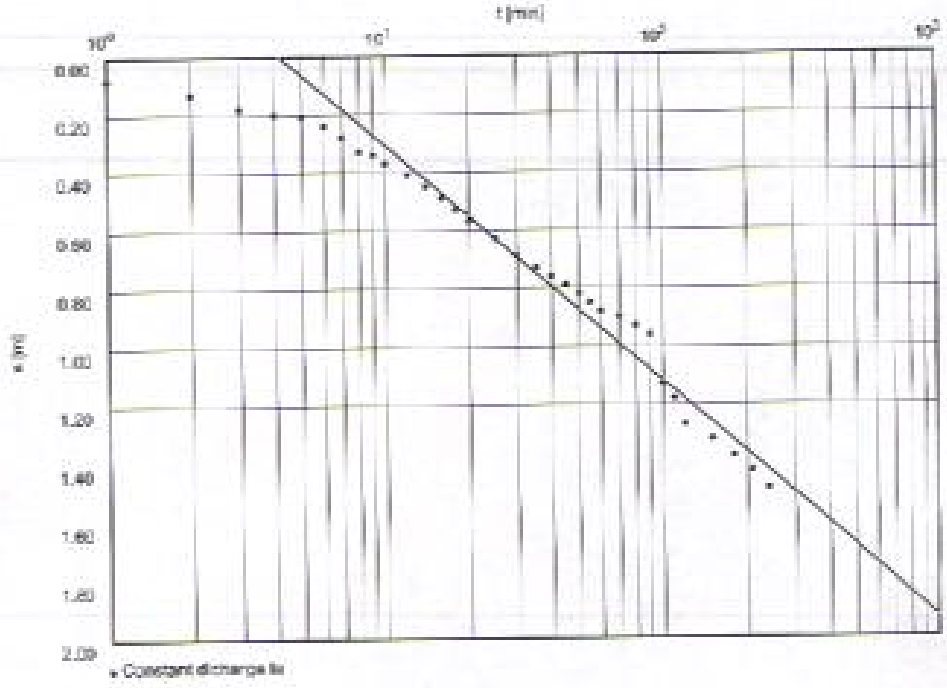
Pumping test analysis
Theis-Drawdown-method after
COOPER & JACOB
Confined aquifer

Date: 08.06.2008 | Page 1
Project: USAID-OFDA
Evaluated by: Gebrehiwot Alefe

Pumping Test No. 1
Test conducted on: 07.02.2003

Arda Berur

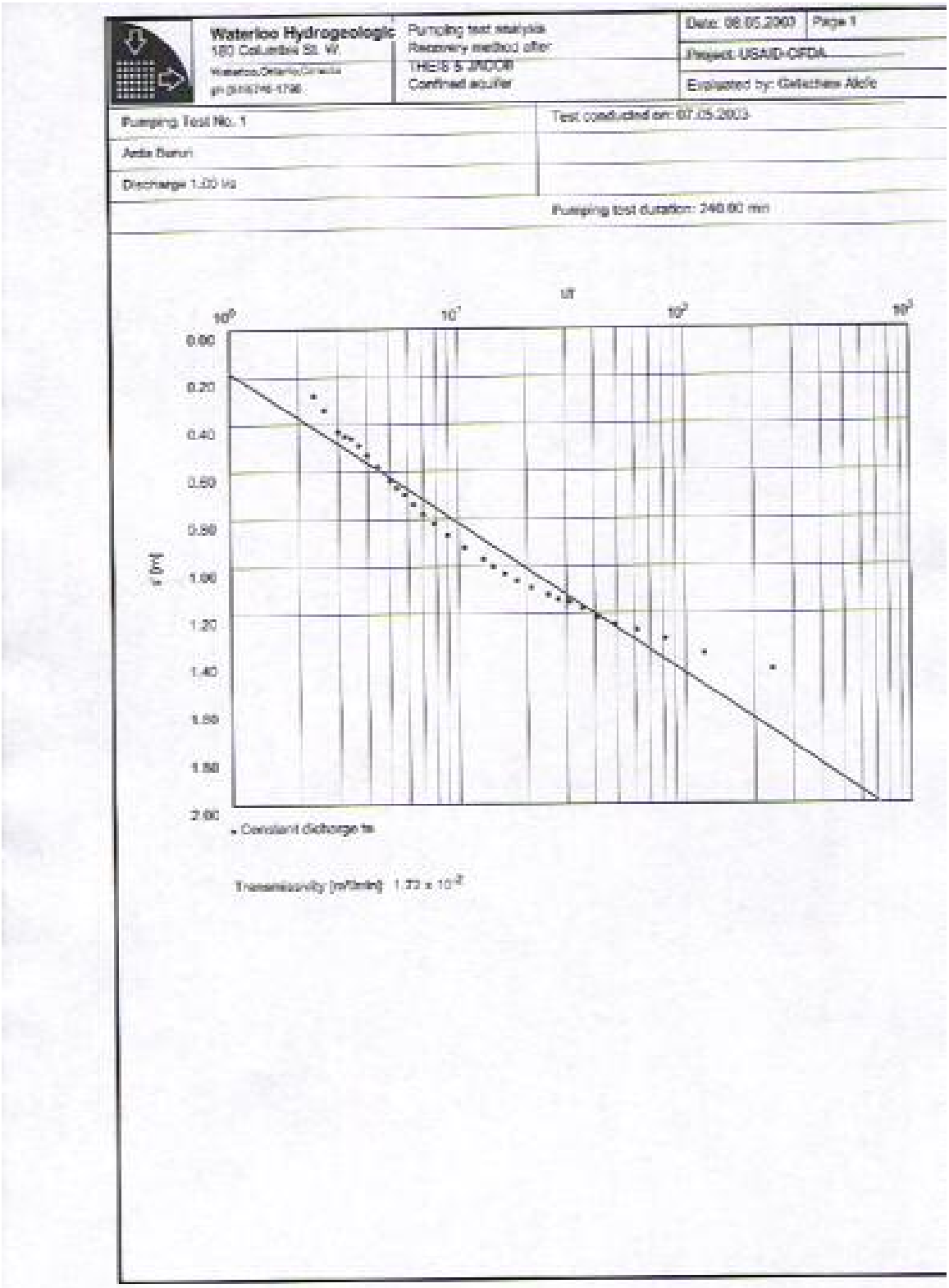
Discharge 1.00 l/s

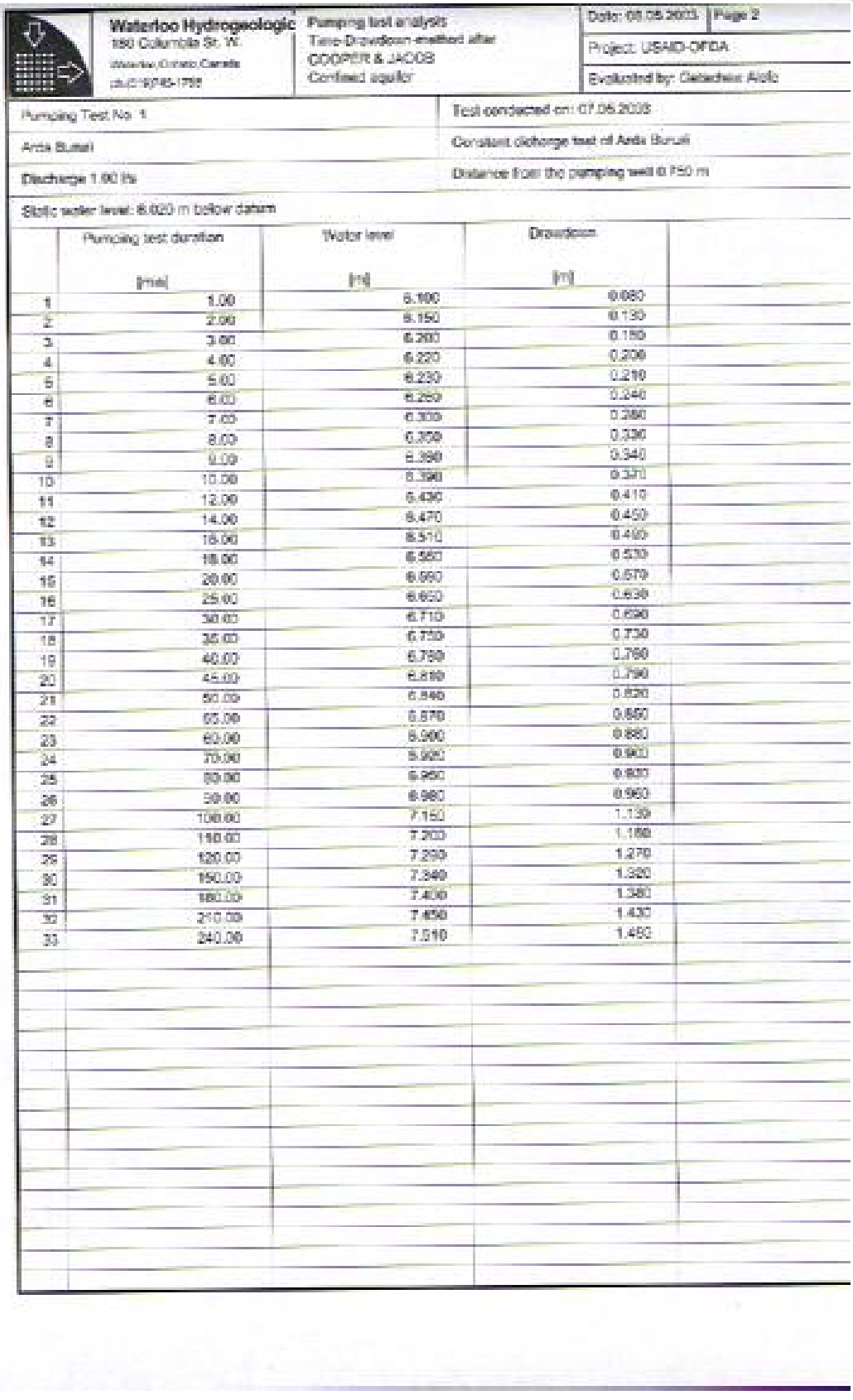


s Constant discharge l/s

Transmissivity [m²/min]: 1.36 x 10⁻³

Storativity: 2.25 x 10⁻¹


Waterloo Hydrogeologic
180 Columbia St. W.
Pumping test analysis
Recovery method after:
THEIS & JACOB
Confined aquifer
Date: 08.05.2003
Page 1
Project: USAID-CRDA
Evaluated by: Gelechew Alelo
Pumping Test No. 1
Test conducted on: 07.05.2003
Jeda Bururi
Discharge 1.20 l/s
Pumping test duration: 240.00 min
t/T
Constant discharge



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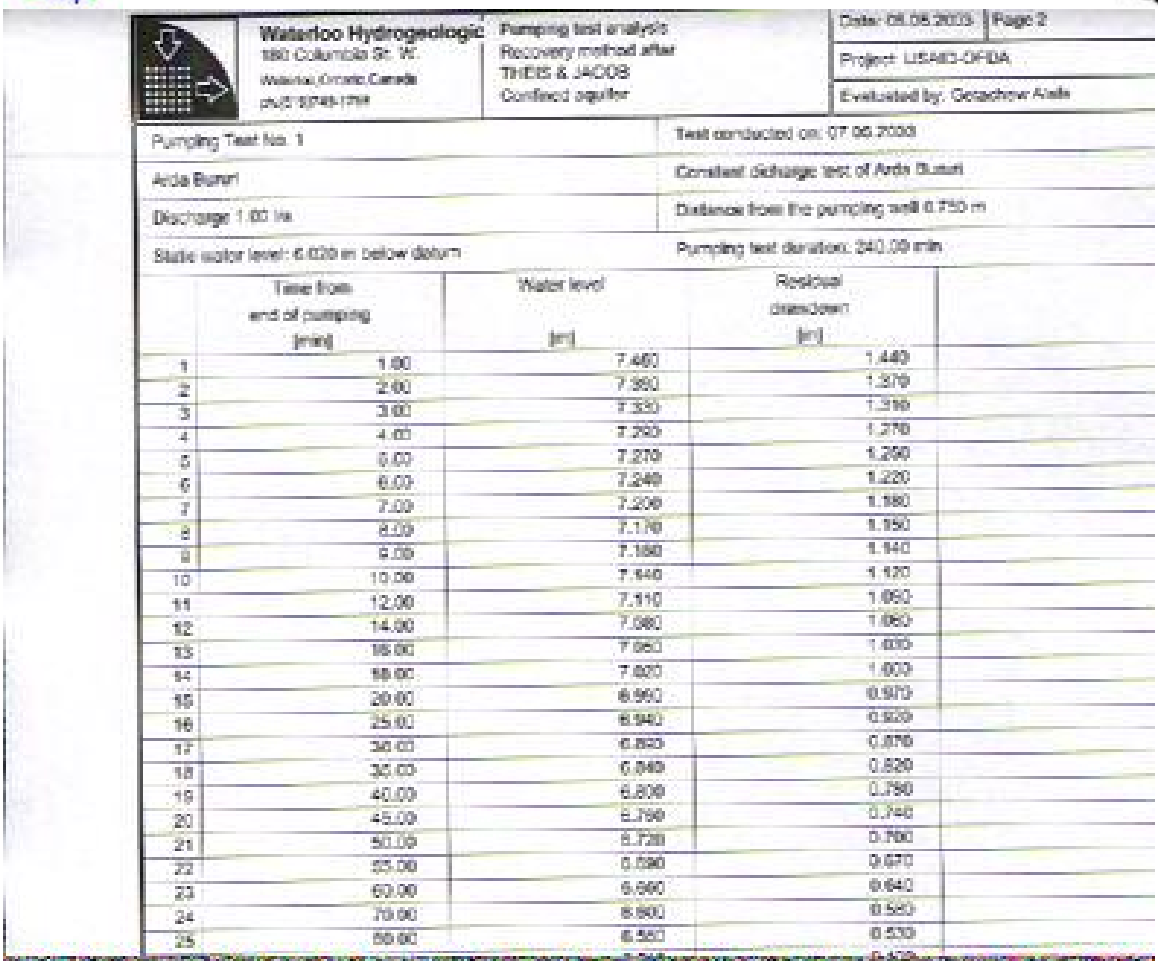
Pumping test analysis
Time-Drawdown-method after
COOPER & JACOB
Confined aquifer

Data: 08.06.2003 | Page 2
Project: USAID-OFDA
Evaluated by: Getachew Alollo

Pumping Test No: 1
Test conducted on: 07.06.2003
Arda Burusi
Constant discharge test at Arda Burusi
Discharge 1.00 l/s
Distance from the pumping well 0.150 m
Static water level: 6.020 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]
1	1.00	6.100	0.080
2	2.00	6.150	0.130
3	3.00	6.200	0.180
4	4.00	6.220	0.200
5	5.00	6.230	0.210
6	6.00	6.260	0.240
7	7.00	6.300	0.280
8	8.00	6.350	0.330
9	9.00	6.360	0.340
10	10.00	6.390	0.370
11	12.00	6.430	0.410
12	14.00	6.470	0.450
13	16.00	6.510	0.490
14	18.00	6.560	0.530
15	20.00	6.590	0.570
16	25.00	6.650	0.630
17	30.00	6.710	0.690
18	35.00	6.750	0.730
19	40.00	6.780	0.760
20	45.00	6.810	0.790
21	50.00	6.840	0.820
22	55.00	6.870	0.850
23	60.00	6.900	0.880
24	70.00	6.920	0.900
25	80.00	6.950	0.930
26	90.00	6.980	0.960
27	100.00	7.150	1.130
28	110.00	7.200	1.180
29	120.00	7.270	1.250
30	150.00	7.340	1.320
31	180.00	7.400	1.380
32	210.00	7.450	1.430
33	240.00	7.510	1.490



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Waterloo, Ontario Canada
ph/f: 519-746-1798

Pumping test analysis
Recovery method after
THEIS & JACOB
Confined aquifer

Date: 08.08.2009 | Page 2
Project: USAID-OFDA
Evaluated by: Gezachew Asale

Pumping Test No. 1 — Test conducted on: 07.08.2009
Arda Burori — Constant dishcarge test of Arda Burori
Discharge: 1.00 l/s — Distance from the pumping well: 0.750 m
Static water level: 6.020 m below datum — Pumping test duration: 240.00 min

	Time from end of pumping [min]	Water level [m]	Residual drawdown [m]
1	1.00	7.460	1.440
2	2.00	7.360	1.340
3	3.00	7.330	1.310
4	4.00	7.290	1.270
5	5.00	7.270	1.250
6	6.00	7.240	1.220
7	7.00	7.200	1.180
8	8.00	7.170	1.150
9	9.00	7.160	1.140
10	10.00	7.140	1.120
11	12.00	7.110	1.090
12	14.00	7.080	1.060
13	16.00	7.060	1.040
14	18.00	7.020	1.000
15	20.00	6.990	0.970
16	25.00	6.940	0.920
17	30.00	6.890	0.870
18	35.00	6.840	0.820
19	40.00	6.800	0.780
20	45.00	6.760	0.740
21	50.00	6.720	0.700
22	55.00	6.690	0.670
23	60.00	6.660	0.640
24	70.00	6.600	0.580
25	80.00	6.560	0.540

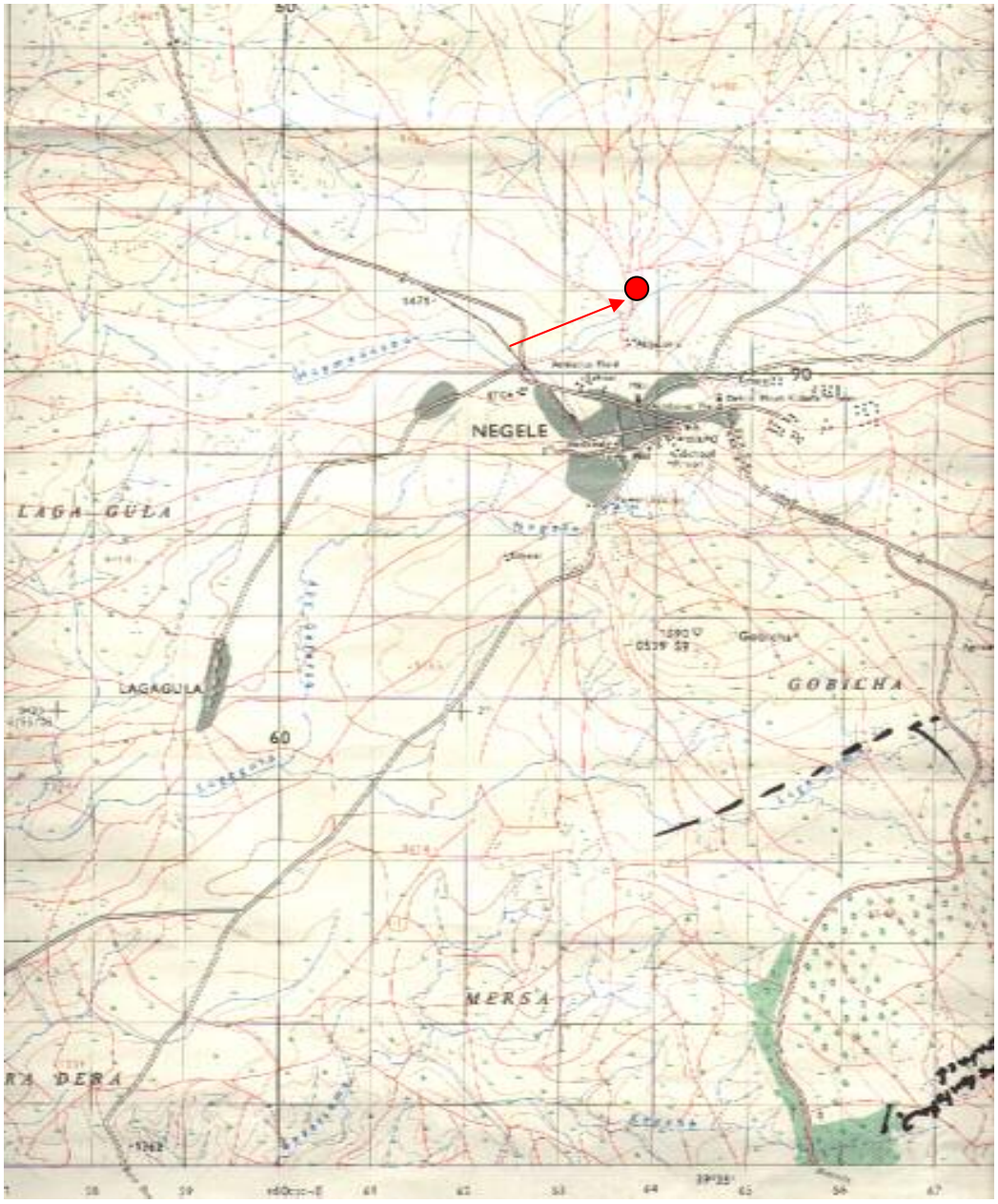
9- Haro

9-1 Location

The site located by in the northwestern part of Negel and it is accessible by dry whether road.In UTM geographic coordinate system the place where the well located appears at:

Zone	37N
East	564297m
North	591332m

Location Map of Haro
Adapted from 1:50,000 topographic map
Of Negele Borena sheet
Sheet no 0539 D1



9-2 Well excavation

Well excavation work started on December16, 2002 and completed on December28, 2003. The diameter of the well was 2.2m, and the final depth of the well is 4.7m. Water stroke at the depth of 2.6m and the static water level inside the well is 0.65m below ground level. The main aquifer of the well is fractured granite.

9-3 casing

Blind as well as slotted concrete ring casings were lowered in to the well according to the following order from the ground level:

Blind 0 up to 1.7m
Screen (slotted rings) 1.7m up to end depth of the well i.e. 4.7m.

The ring is further rise 0.80m above ground level to prevent flooding and to permit the well head structure. The diameter of the rings is same for all and it is 1.5 in the internal part and 1.7m in the outer part.

9-4 Packing

The well annular space packed by selected river gravel from the depth of 1.25m up to the bottom of the hole to facilitate the in flow of water into the well and to server as filtering media. The rest part of the well was packed by clay and with o.25m thick cement in order to prevent the percolation of surface water in to the well.

9-5 Well log

Samples were continuously observed in order to identify the lithological layering, and the samples are used to set the well log. The well lithological log and the well casing as well as packing design are shown on the following chart.

9-6 Pumping test

Constant discharge test was adapted for the well test. The test carried out for total of 480 minutes including the recovery test, and the data obtained from the test is used in Cooper and Jacob equations to calculate transimisivity. Theis and Cooper method applied for the recovery test. The general information regarding the test is presented below and the results obtained from the analysis are presented in the next consecutive pages.

Date of test 30/04/2003	Constant Dicharge Test
Location: Zone Borena	SWL 1.21m
District Liben	Ref.Point 0.80m A.G.L
Kebele Haro	Q(lit/sec) 1.20

9-7 Water quality

Water sample had taken in the end period of the pumping test. The sample tested for some drinking water quality parameters and the result obtained from the test listed below.

Conductivity	1392 µs/cm
Temperature	24.7^0c
Total Hardness	Medium hard
Chloride Cl-	150mg/lit
Ph	7
Nitrate	10mg/lit
Ammonium	nill
Nitrite	nill
Sulphate	<200ppm

9-8 Well head and fencing

The well head constructed on the well is the usual COOPI standard well head i.e. 4m*4m with concrete slab on top. First the structure rise from the ground to sufficient height (average=0.60m) by masonry and on top covered by reinforced concrete slab with manhole and inlet hole for both hand pump.

After the well head construction INDIAN MARK II hand pump installed, and finally the well site fenced by barbed wire with support of angle iron.

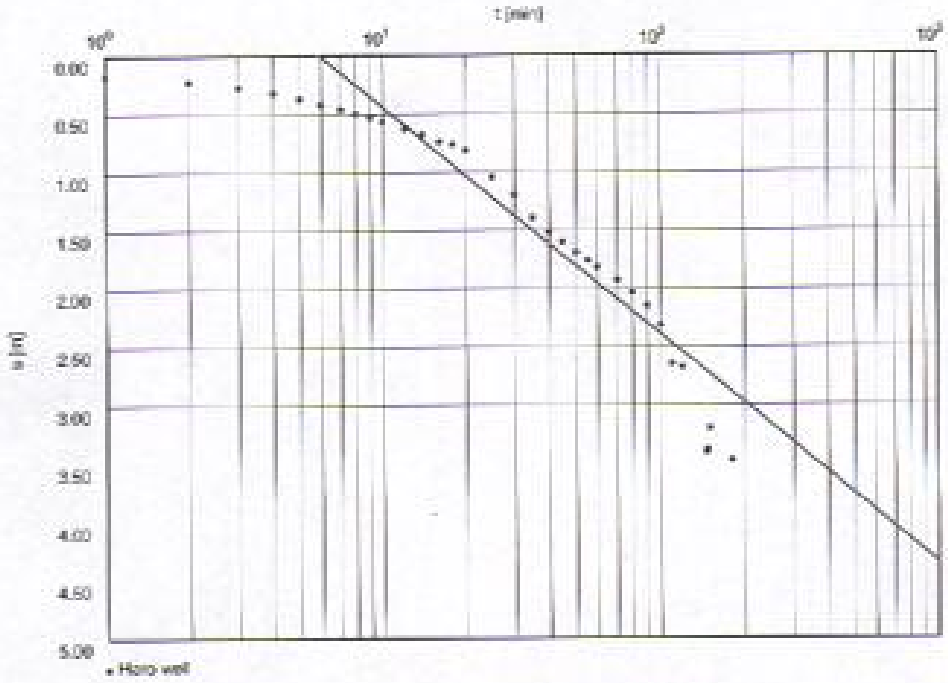
Waterloo Hydrogeologic 160 Columbia St. W. Waterloo, Ontario, Canada ph.(519)746-1798	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 01.05.2009	Page 1
		Project: USAID-OFDA	
		Evaluated by:	

Pumping Test No.: 1

Test conducted on: 30.04.2009

Hand-1

Discharge 1.26 l/s



Transmissivity [m²/sec]: 6.75×10^{-3}

Storativity: 1.60×10^{-1}

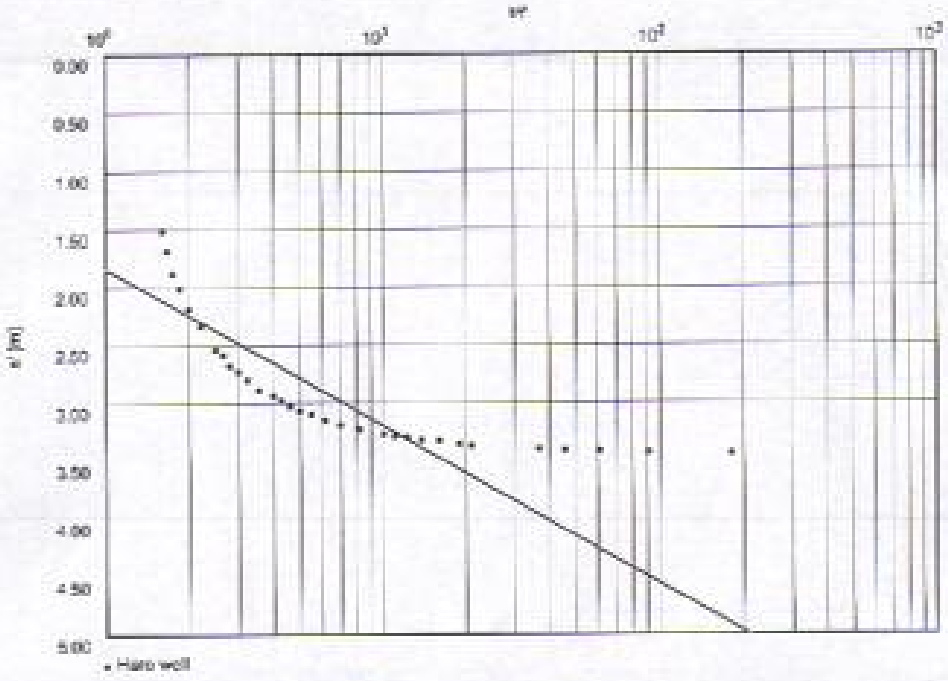
Waterloo Hydrogeologic 160 Columbia St. W Waterloo, Ontario, Canada ph (519) 746-1798	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 01.05.2003	Page 1
		Project: USAID-OFDA	
		Evaluated by:	

Pumping Test No.: 1 — Test conducted on: 30.04.2003

Well-1

Discharge: 1.20 l/s

Pumping test duration: 180.00 min



Transmissivity [m²/min]: 9.60 x 10^-2

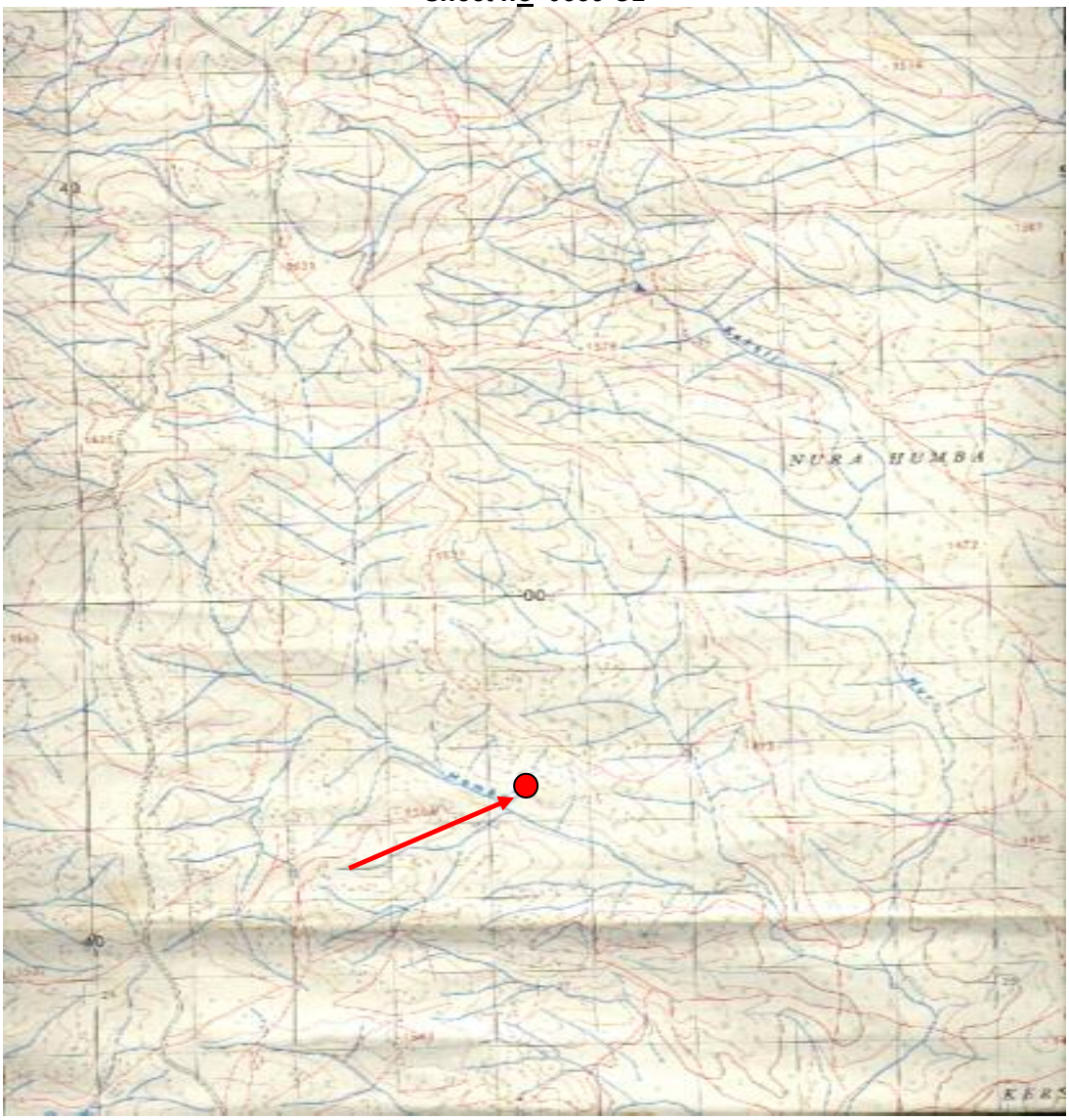
10- Mede

10-1 Location

The site located by Northwest of Negele and it is accessible by 12Km long dry weather access road from Negele-Bitata main road. In UTM geographic coordinate system the place where the well located appears at:

Zone	37N
East	544173m
North	597521m

Location Map of Mede
Adapted from 1:50,000 topographic map
Of Bitata sheet
Sheet no 0539 C2



10-2 Well excavation

Well excavation work started in April 2003 and first 5.85hole excavated. But the hole abandoned because of heavy collapsing encountered before lowering of concrete rings. The excavation work once again restarted in May and completed on June23, 2003. The diameter of the well was 2.2m, and the final depth of the well is 8.1m. Water stroke at the depth of 4.2m and the static water level inside the well is 3.8m below ground level. The main aquifer of the well is sand.

10-3 casing

Blind as well as slotted concrete ring casings were lowered in to the well according to the following order from the ground level:

Blind 0 up to 5.1m
Screen (slotted rings) 5.1m up to end depth of the well i.e. 8.1m.

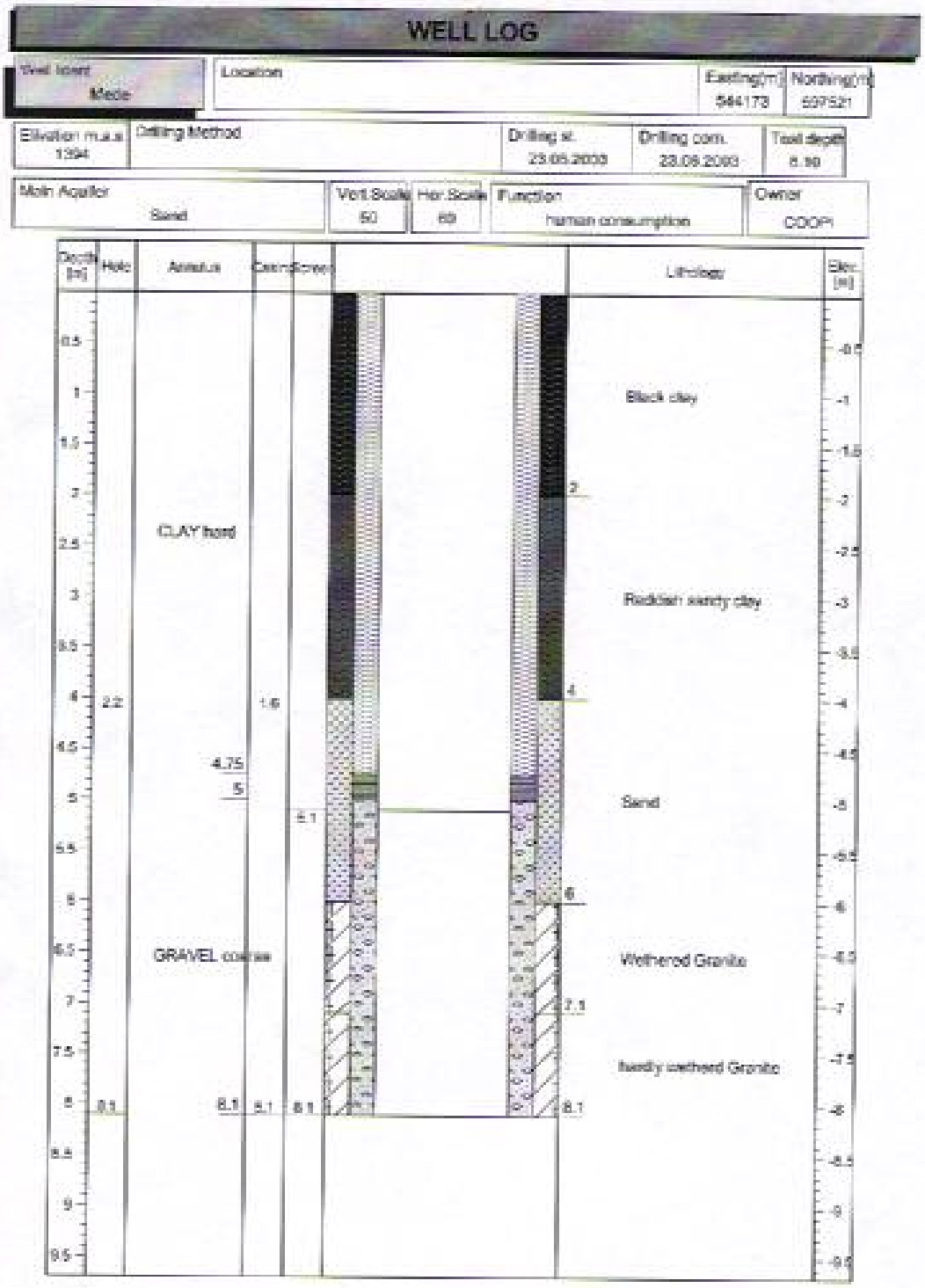
The ring is further rise 0.60m above ground level to prevent flooding and to permit the well head structure. The diameter of the rings is same for all and it is 1.5 in the internal part and 1.7m in the outer part.

10-4 Packing

The well annular space packed by selected river gravel from the depth of 5m up to the bottom of the hole to facilitate the in flow of water into the well and to server as filtering media. The rest part of the well was packed by clay and cement in order to prevent the percolation of surface water in to the well.

10-5 Well log

Samples were continuously observed in order to identify the lithological layering and the samples were used to set the well log. The well lithological log and the well casing as well as packing design are shown on the following chart.


WELL LOG
Well Ident
Mede
Location
Easting[m]
564173
Northing[m]
597521
Elivation m.a.s
1394
Drilling Method
Drilling st.
23.05.2003
Drilling com.
28.05.2003
Total depth
8.10
Main Aquifer
Sand
Vert.Scale
50
Hor.Scale
69
Function
human consumption
Owner
COOPI
Depth [m]
Hole
Annulus
Casing
Screen
Lithology
Elev. [m]
CLAY hard
GRAVEL coarse
Black clay
Reddish sandy clay
Sand
Weathered Granite
hardly weathered Granite
2.2
1.6
4.75
5
6.1
2
4
6
7.1
8.1
0.1

10-6 Pumping test

The test carried out for total of 420 minutes including the recovery test. Theis and Cooper method applied for the recovery test. The general information regarding the test is presented below and the results obtained from the analysis are presented in the next consecutive pages.

Date of test 29/07/2003	Recovery test
Location: Zone Borena	SWL 5.1m
District Liben	Ref.Point 0.80m A.G.L
Kebele Mede	Q(lit/sec) 1

10-7 Water quality

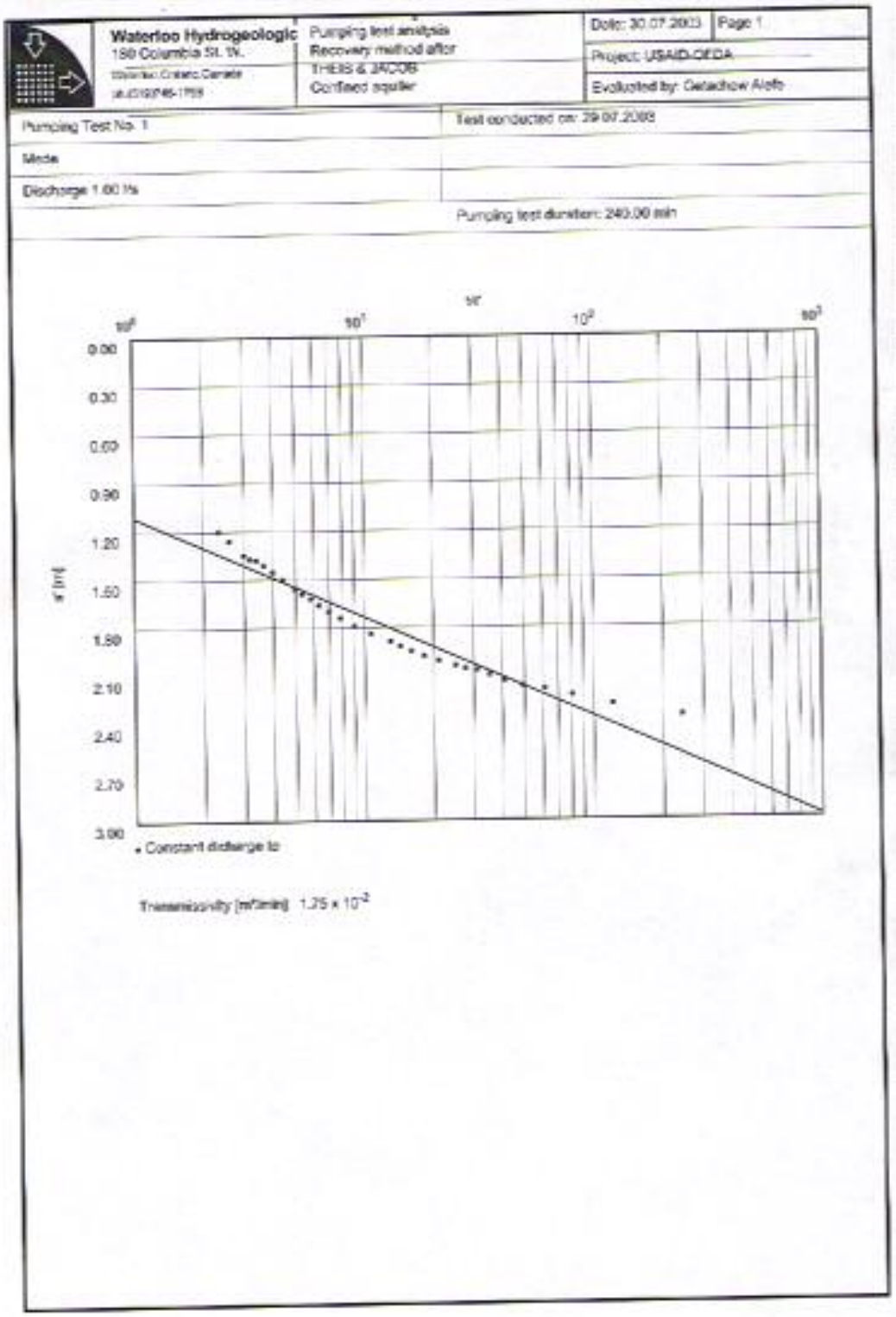
Water sample had taken in the end period of the pumping test. The sample tested for some drinking water quality parameters and the result obtained from the test listed below.

Conductivity	912 µs/cm
Temperature	22.7^{0}c
Total Hardness	Medium hard
Chloride Cl-	75mg/lit
Ph	7.5
Nitrate	nill
Ammonium	nill
Nitrite	nill
Sulphate	<200ppm

10-8 Well head and fencing

The well head constructed on the well is the usual COOPI standard well head i.e. 4m*4m with concrete slab on top. First the structure rise from the ground to sufficient height (average=0.60m) by masonry and on top covered by reinforced concrete slab with manhole and inlet hole for both hand pump.

After the well head construction INDIAN MARK II hand pump installed, and finally the well site fenced by barbed wire with support of angle iron.



Waterloo Hydrogeologic
160 Columbia St. W.
Waterloo, Ontario, Canada
tel.(519)746-1798

Pumping test analysis
Recovery method after
THEIS & JACOB
Confined aquifer

Date: 30.07.2003 | Page: 1
Project: USAID-OFDA
Evaluated by: Getachow Alefe

Pumping Test No. 1
Test conducted on: 29.07.2003
Wells
Discharge 1.00 l/s
Pumping test duration: 240.00 min

s' [m]
0.00
0.30
0.60
0.90
1.20
1.50
1.80
2.10
2.40
2.70
3.00

10^0 10^1 10^2 10^3 t/t'

• Constant discharge to

Transmissivity [m²/min] 1.25×10^{-2}

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180 Columbia St. W.
Waterloo Ontario Canada
ph (519)746-1798

Pumping test analysis
Recovery method after
THEIS & JACOB
Confined aquifer

Date: 30.07.2003 | Page 2
Project: USAID-OFDA
Evaluated by: Getachew Alalie

Pumping Test No. 1
Test conducted on: 28.07.2003
Meda
Mode: Recovery test
Discharge 1.00 l/s
Distance from the pumping well: 0.750 m
Static water level: 5.100 m below datum
Pumping test duration: 240.00 min

	Time from end of pumping [min]	Water level [m]	Residual drawdown [m]
1	1.00	7.460	2.360
2	2.00	7.350	2.250
3	3.00	7.330	2.230
4	4.00	7.290	2.190
5	5.00	7.270	2.170
6	6.00	7.240	2.140
7	7.00	7.200	2.100
8	8.00	7.170	2.070
9	9.00	7.160	2.060
10	10.00	7.140	2.040
11	12.00	7.110	2.010
12	14.00	7.080	1.980
13	16.00	7.050	1.950
14	18.00	7.020	1.920
15	20.00	6.990	1.890
16	25.00	6.940	1.840
17	30.00	6.890	1.790
18	35.00	6.840	1.740
19	40.00	6.800	1.700
20	45.00	6.760	1.660
21	50.00	6.720	1.620
22	55.00	6.690	1.590
23	60.00	6.660	1.560
24	70.00	6.600	1.500
25	80.00	6.550	1.450
26	90.00	6.510	1.410
27	100.00	6.480	1.380
28	110.00	6.470	1.370
29	120.00	6.450	1.350
30	150.00	6.360	1.260
31	180.00	6.300	1.200

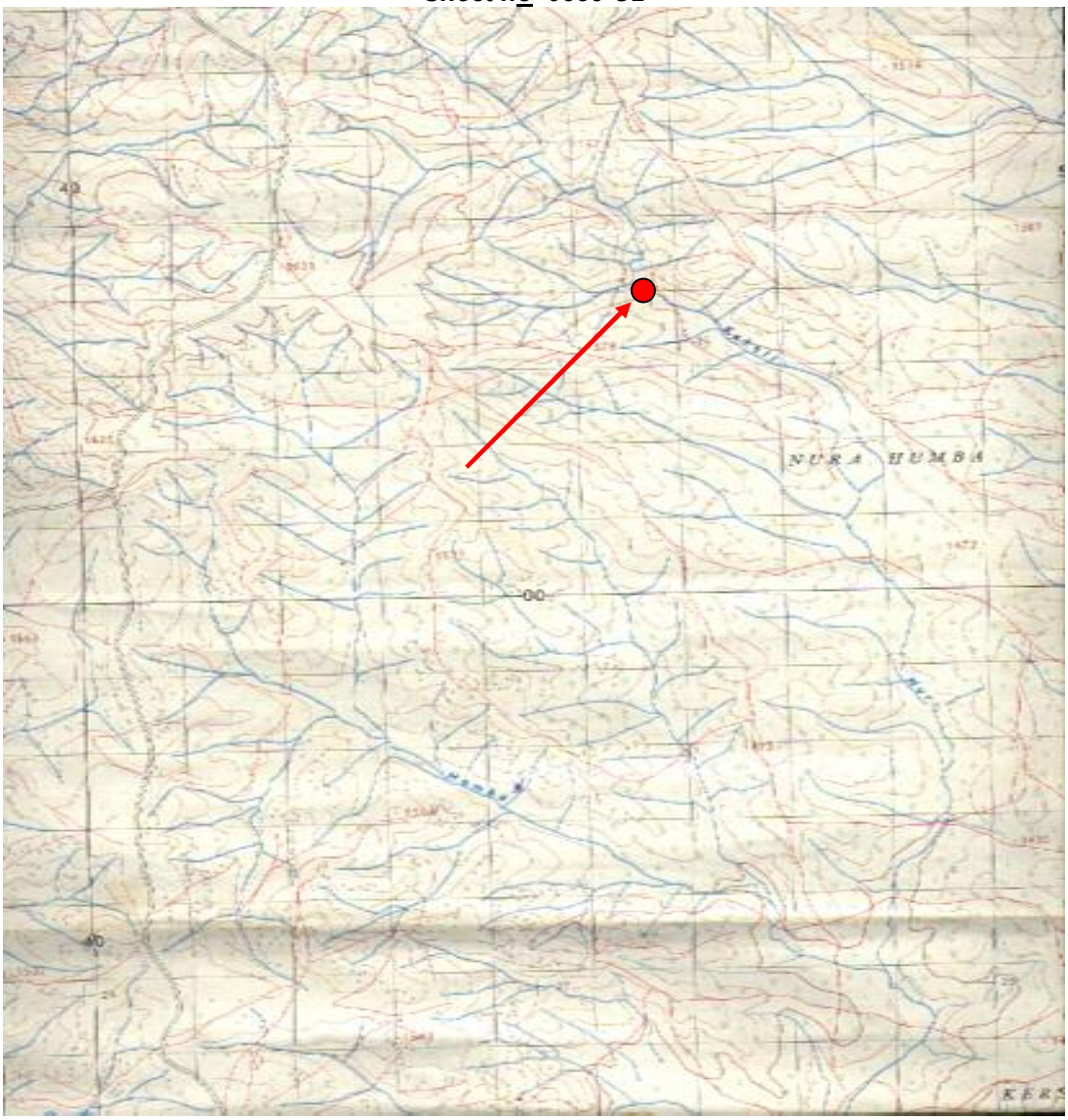
11- Nura Amba

11-1 Location

The site located by Northwest of Negele and it is accessible by 7Km long dry weather access road from Negele-Bitata main road. It total distance from Negele is 27 Km. In UTM geographic coordinate system the place where the well located appears at:

Zone	37N
East	545829m
North	604140m

Location Map of Nura Amba
Adapted from 1:50,000 topographic map
Of Bitata sheet
Sheet no 0539 C2



11-2 Well excavation

Well excavation work started in March 2003 and first 7m hole excavated. But the hole abandoned because of heavy collapsing encountered before lowering of concrete rings. The excavation work once again restarted on April19, 2003 and completed on June10, 2003. The diameter of the well was 2.2m, and the final depth of the well is 7.5m. Water stroke at the depth of 3m and the static water level inside the well is 2.2m below ground level. The main aquifer of the well is weathered Gneiss.

11-3 casing

Blind as well as slotted concrete ring casings were lowered in to the well according to the following order from the ground level:

Blind 0 up to 4.5m
Screen (slotted rings) 4.5m up to end depth of the well i.e. 7.5m.

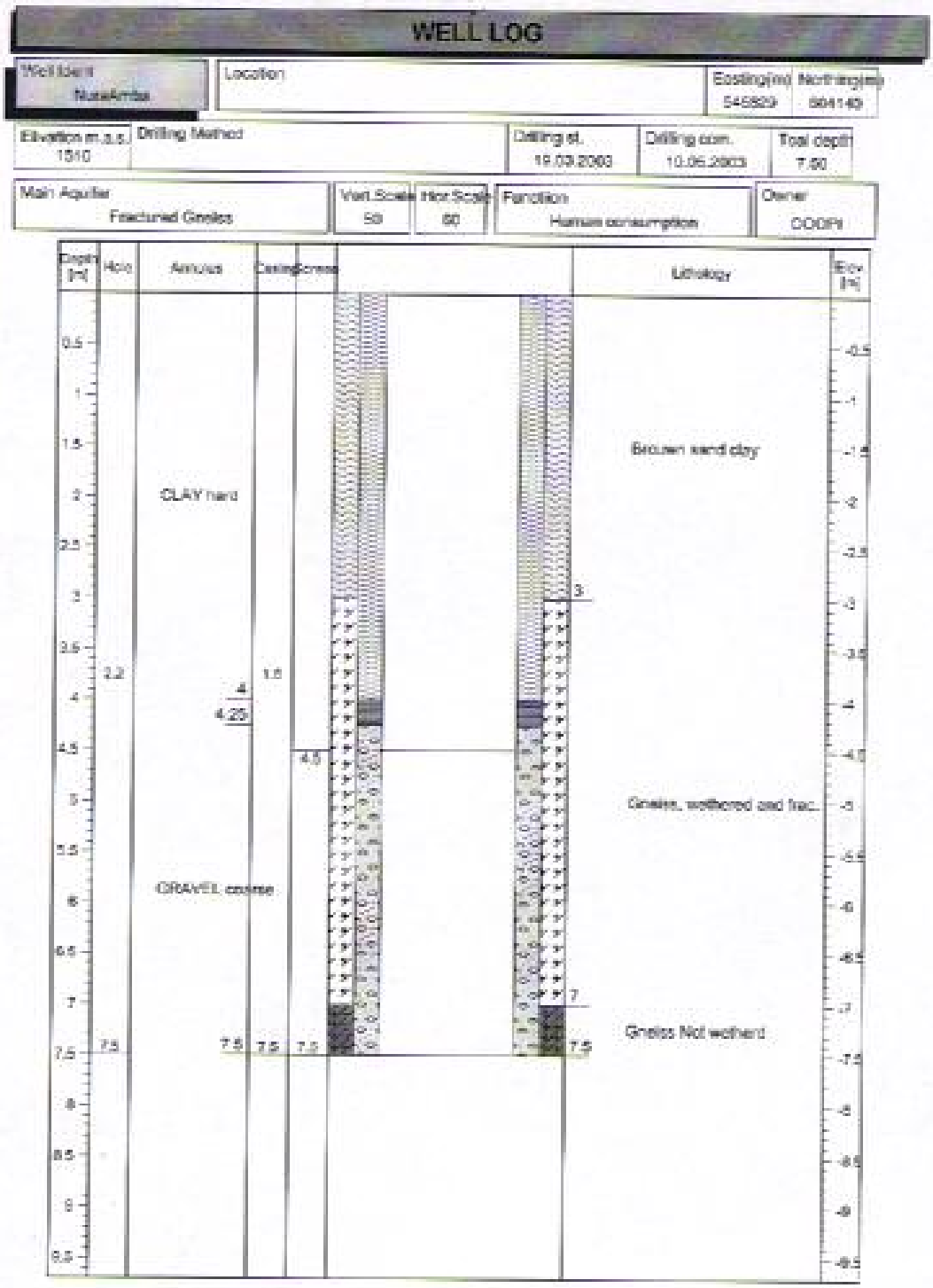
The ring is further rise 0.60m above ground level to prevent flooding and to permit the well head structure. The diameter of the rings is same for all and it is 1.5 in the internal part and 1.7m in the outer part.

11-4 Packing

The well annular space packed by selected river gravel from the depth of 4.25m up to the bottom of the hole to facilitate the in flow of water into the well and to server as filtering media. The rest part of the well was packed by clay and cement in order to prevent the percolation of surface water in to the well.

11-5 Well log

Samples were continuously observed in order to identify the lithological layering and the samples were used to set the well log. The well lithological log and the well casing as well as packing design are shown on the following chart.


WELL LOG
Location
Drilling Method
Main Aquifer
Fractured Gneiss
Function
Human consumption
Owner
COOPI
Depth [m]
Annulus
Lithology
Brown sand clay
CLAY hard
GRAVEL coarse
Gneiss, weathered and frac.
Gneiss Not wethard

11-6 Pumping test

Constant discharge test was adapted for the well test. The test carried out for total of 600 minutes including the recovery test, and the data obtained from the test is used in Cooper and Jacob equations to calculate transimisivity. Theis and Cooper method applied for the recovery test. The general information regarding the test is presented below and the results obtained from the analysis are presented in the next consecutive pages.

Date of test 20/06/2003	Constant Discharge Test
Location: Zone Borena	SWL 2.8m
District Liben	Ref.Point 0.80m A.G.L
Kebele Nura Amba	Q(lit/sec) 0.6m

11-7 Water quality

Water sample had taken in the end period of the pumping test. The sample tested for some drinking water quality parameters and the result obtained from the test listed below.

Conductivity	1392 µs/cm
Temperature	24.7^0c
Total Hardness	Medium hard
Chloride Cl-	150mg/lit
Ph	7
Nitrate	10mg/lit
Ammonium	nill
Nitrite	nill
Sulphate	<200ppm

11-8 Well head and fencing

The well head constructed on the well is the usual COOPI standard well head i.e. 4m*4m with concrete slab on top. First the structure rise from the ground to sufficient height (average=0.60m) by masonry and on top covered by reinforced concrete slab with manhole and inlet hole for both hand pump.

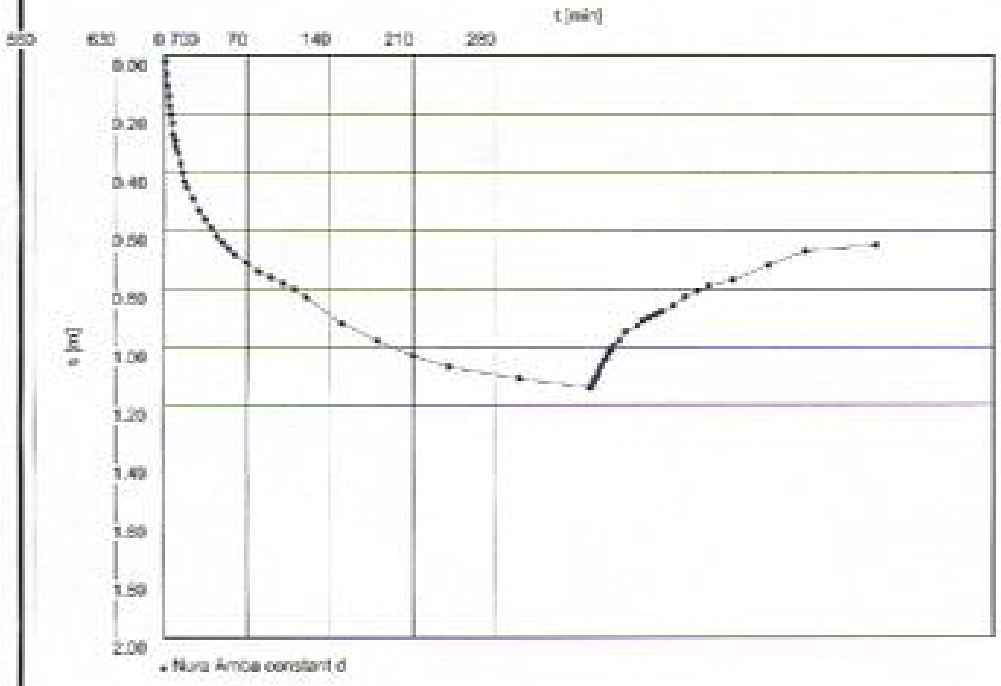
After the well head construction INDIAN MARK II hand pump installed, and finally the well site fenced by barbed wire with support of angle iron.

Waterloo Hydrogeologic 160 Columbia St. W.	Pumping test analysis Time-Drawdown plot	Date: 27.06.2003	Page 1
		Project: USAID-OFDA	
		Evaluated by:	

Pumping Test No.: Test conducted on: 20.05.2003

Nura Amba

Discharge: 1.80 l/s



Waterloo Hydrogeologic
180 Columbia St. W.
Waterloo,Ontario,Canada
ph(519)746-1798

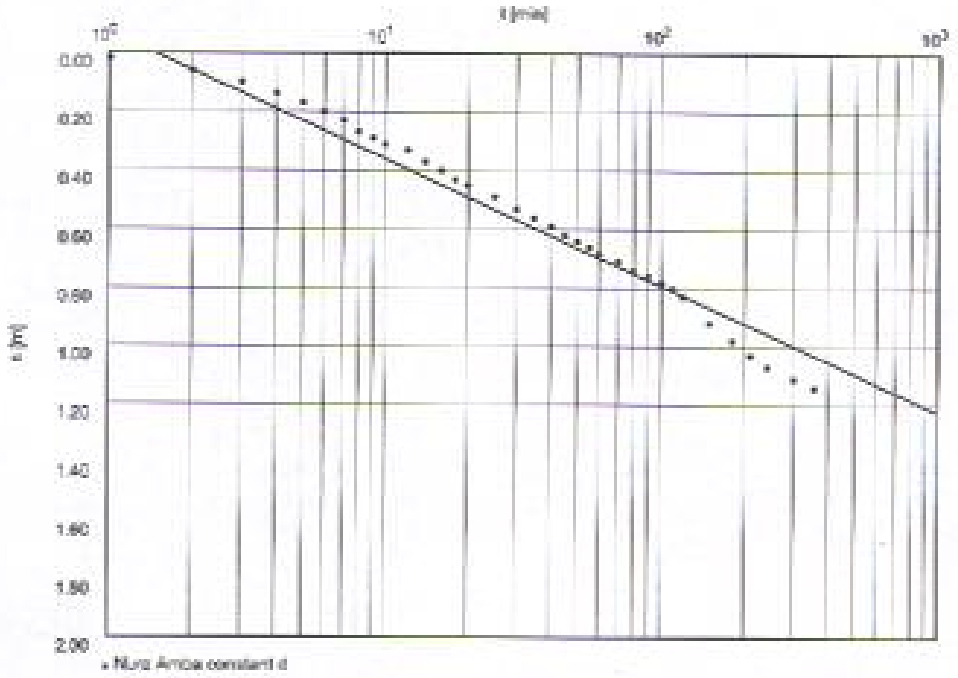
Pumping test analysis
Time-Drawdown-method after
COOPER & JACOB
Confined aquifer

Date: 27.09.2003 | Page 1
Project: USAID-GTDA
Evaluated by:

Pumping Test No.: | Test conducted on: 20.09.2003

Nuro Amba

Discharge 1.89 l/s



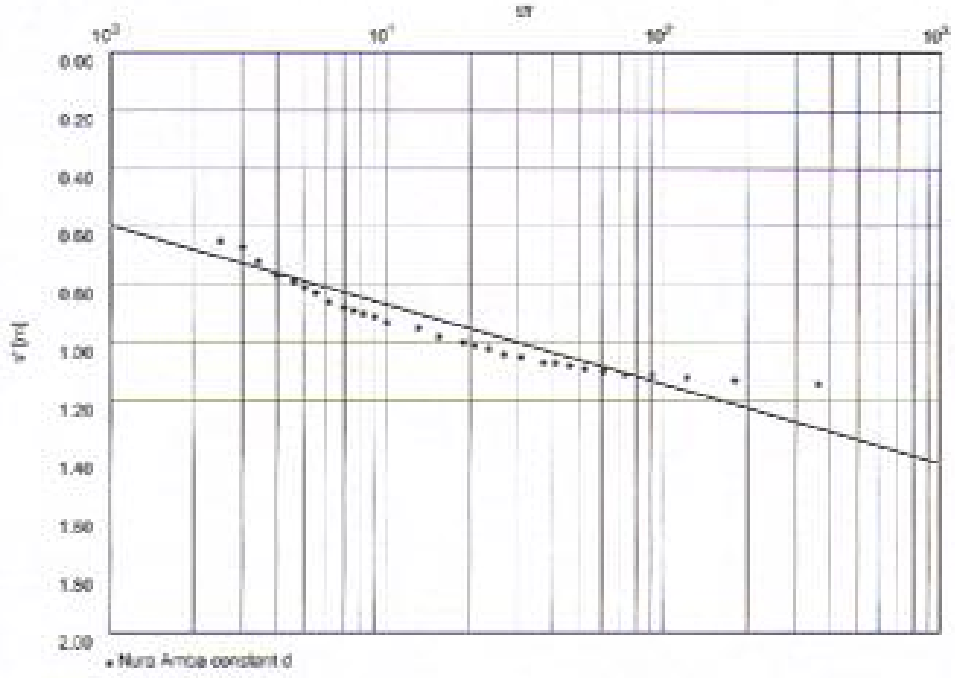
s: Nuro Amba constant d

Transmissivity [m²/min]: 4.81 x 10^{-2}

Storativity: 2.79 x 10^{-1}

Waterloo Hydrogeologic 180 Columbia St. W. Waterloo,Ontario,Canada	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 27.05.2003	Page 1
		Project: USAID-CRDA	
		Evaluated by	

Pumping Test No.	Test conducted on: 20.06.2009
Nura Arroe	
Discharge 1.99 l/s	
	Pumping test duration: 360.00 min



+ Nura Arroe constant d

Transmissivity [m²/min] 7.60×10^{-2}

Waterloo Hydrogeologic 160 Columbia St. W. Waterloo, Ontario, Canada ph.(519)746-1798	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 27.06.2009	Page 2
		Project: USAID-OFDA	
		Evaluated by:	

Pumping Test No.	Test conducted on: 20.06.2009
Nura Amba	Nura Amba constant dis. test
Discharge 1.89 l/s	Distance from the pumping well: 0.750 m
Static water level: 2.800 m below datum	Pumping test duration: 360.00 min

	Time from start of pumping [min]	Water level [m]	Residual drawdown [m]
1	1.00	3.940	1.140
2	2.00	3.930	1.130
3	3.00	3.920	1.120
4	4.00	3.910	1.110
5	5.00	3.910	1.110
6	6.00	3.900	1.100
7	7.00	3.890	1.090
8	8.00	3.880	1.080
9	9.00	3.870	1.070
10	10.00	3.870	1.070
11	12.00	3.860	1.060
12	14.00	3.840	1.040
13	16.00	3.820	1.020
14	18.00	3.810	1.010
15	20.00	3.800	1.000
16	25.00	3.780	0.980
17	30.00	3.750	0.950
18	40.00	3.730	0.930
19	45.00	3.710	0.910
20	50.00	3.700	0.900
21	55.00	3.690	0.890
22	60.00	3.680	0.880
23	70.00	3.660	0.860
24	80.00	3.650	0.850
25	90.00	3.610	0.810
26	100.00	3.590	0.790
27	120.00	3.570	0.770
28	150.00	3.520	0.720
29	180.00	3.470	0.670
30	240.00	3.450	0.650

Waterloo Hydrogeologic 109 Columbia St. W. Waterloo, Ontario, Canada ph (519)725-1796	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 27.06.2003	Page 2
		Project: USAID-OFDA	
		Evaluated by:	

Pumping Test No.	Test conducted on: 20.06.2003
Nura Amba	Nura Amba constant dis. test
Discharge 1.89 l/s	Distance from the pumping well 0.750 m

Static water level: 2.809 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]
1	1.00	2.820	0.020
2	2.00	2.860	0.060
3	3.00	2.900	0.100
4	4.00	2.940	0.140
5	5.00	2.970	0.170
6	6.00	3.000	0.200
7	7.00	3.030	0.230
8	8.00	3.070	0.270
9	9.00	3.090	0.290
10	10.00	3.110	0.310
11	12.00	3.130	0.330
12	14.00	3.170	0.370
13	16.00	3.200	0.400
14	18.00	3.230	0.430
15	20.00	3.250	0.450
16	22.00	3.290	0.490
17	30.00	3.330	0.530
18	36.00	3.360	0.560
19	40.00	3.390	0.590
20	46.00	3.420	0.620
21	56.00	3.440	0.640
22	66.00	3.460	0.660
23	68.00	3.480	0.680
24	78.00	3.510	0.710
25	88.00	3.540	0.740
26	98.00	3.560	0.760
27	108.00	3.580	0.780
28	118.00	3.600	0.800
29	128.00	3.630	0.830
30	150.00	3.720	0.920
31	180.00	3.780	0.980
32	210.00	3.830	1.030
33	240.00	3.870	1.070
34	300.00	3.910	1.110
35	360.00	3.940	1.140

ABANDONED WELLS

This part includes those wells, which are abandoned because of either low productivity of the hole or poor quality of water from the respective holes. The abandoned well sites are four in number, the name of the sites are listed below:

a) Shishu
b) Bitata Bura
c) Jidola
d) Kobo

a) Shishu

The site located along the road to Genale Village at distance of 46Km from Negele. The final depth of the hole is 13.7m. There was no any saturated layer up to the mentioned depth, only 6.2m thick wet sand encountered from the depth of 7.3m up to 13.5m.

b) Bitata Bura

Two holes were excavated in Bitata Bura. The depth of the first well was 6.6m and it was dry. The second hole located in the near by of the first well after detail geo-electrical survey. Unlike to the first one, the second well was not dry, but it is abandoned because poor quality of the water.

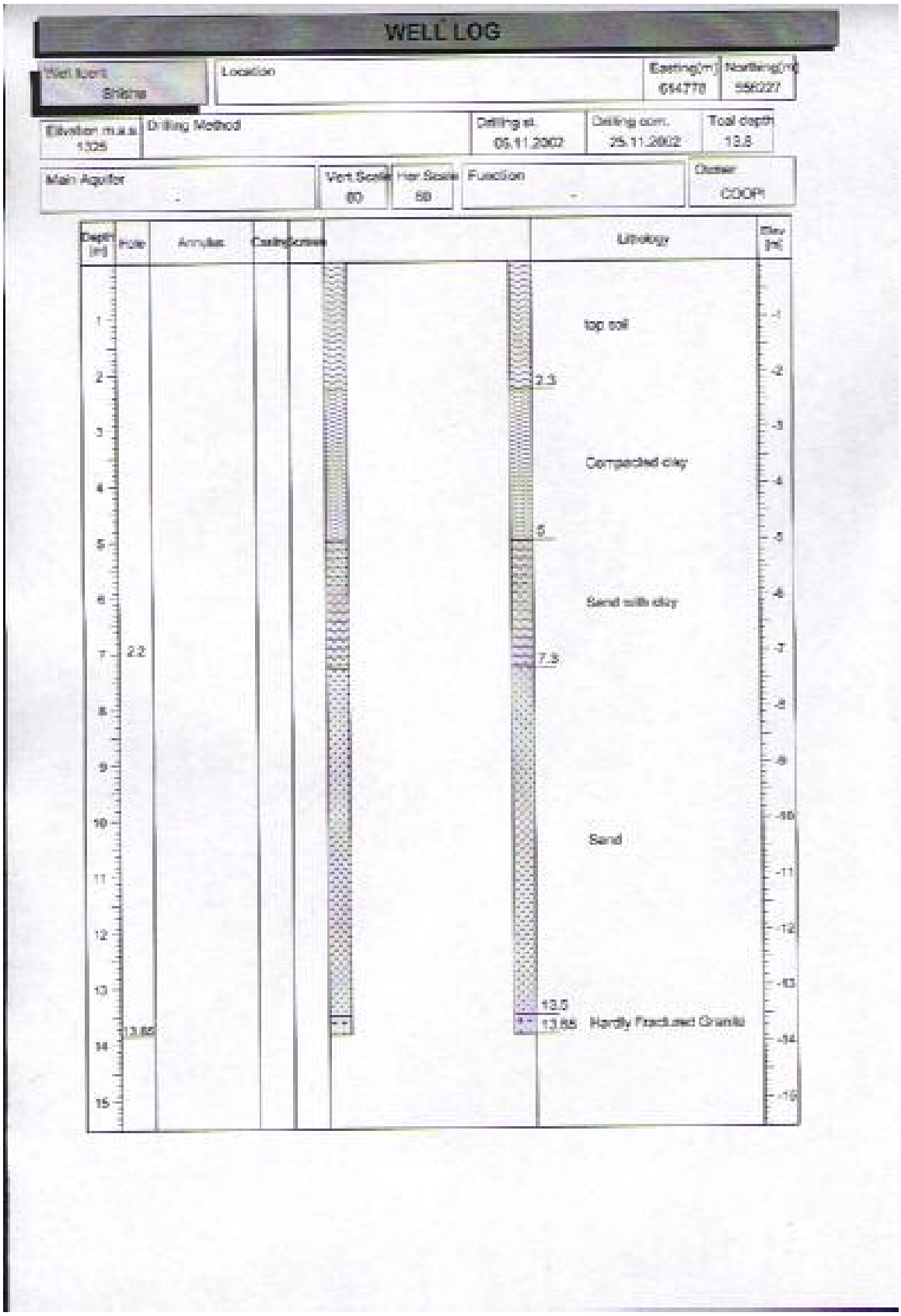
Conductivity	11,280 µs/cm
Temperature	22.7^0c
Total Hardness	Medium hard
Chloride Cl-	>2,000 mg/litt
Ph	7.5
Nitrate	nill
Ammonium	nill
Nitrite	nill
Sulphate	<200ppm

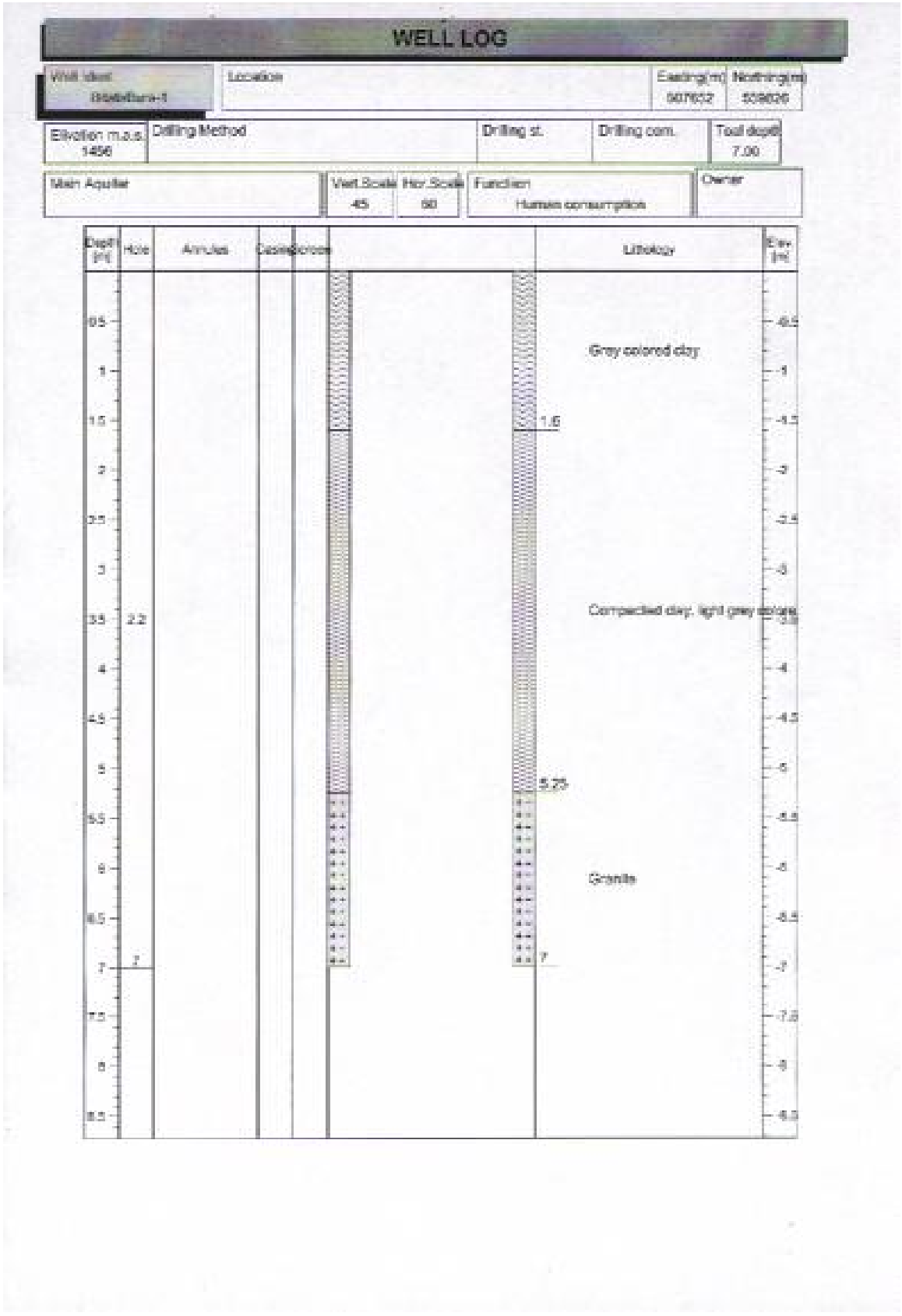
C) Jidola

The sites are located in the vicinity of Jidola village. The distance of the site from Negele is 68km. 4.8m deep hole excavated but no water encountered.

D) Kobo

Its distance from Negele is around 47Km and 2m deep hole was excavated but encountered massive rock layer.


WELL LOG
Well Num
Shilina
Location
Easting(m)
694778
Northing(m)
556027
Elevation m.a.s.l
1325
Drilling Method
Drilling st.
05.11.2002
Drilling com.
25.11.2002
Total depth
13.8
Main Aquifer
Vert.Scale
80
Hor.Scale
80
Function
Owner
COOPI
Depth [m]
Hole
Annulus
Casing
Screen
Lithology
Elev [m]
top soil
2.3
Compacted clay
5
Sand with clay
7.9
2.2
Sand
13.0
13.85
Hardly Fractured Granite
13.85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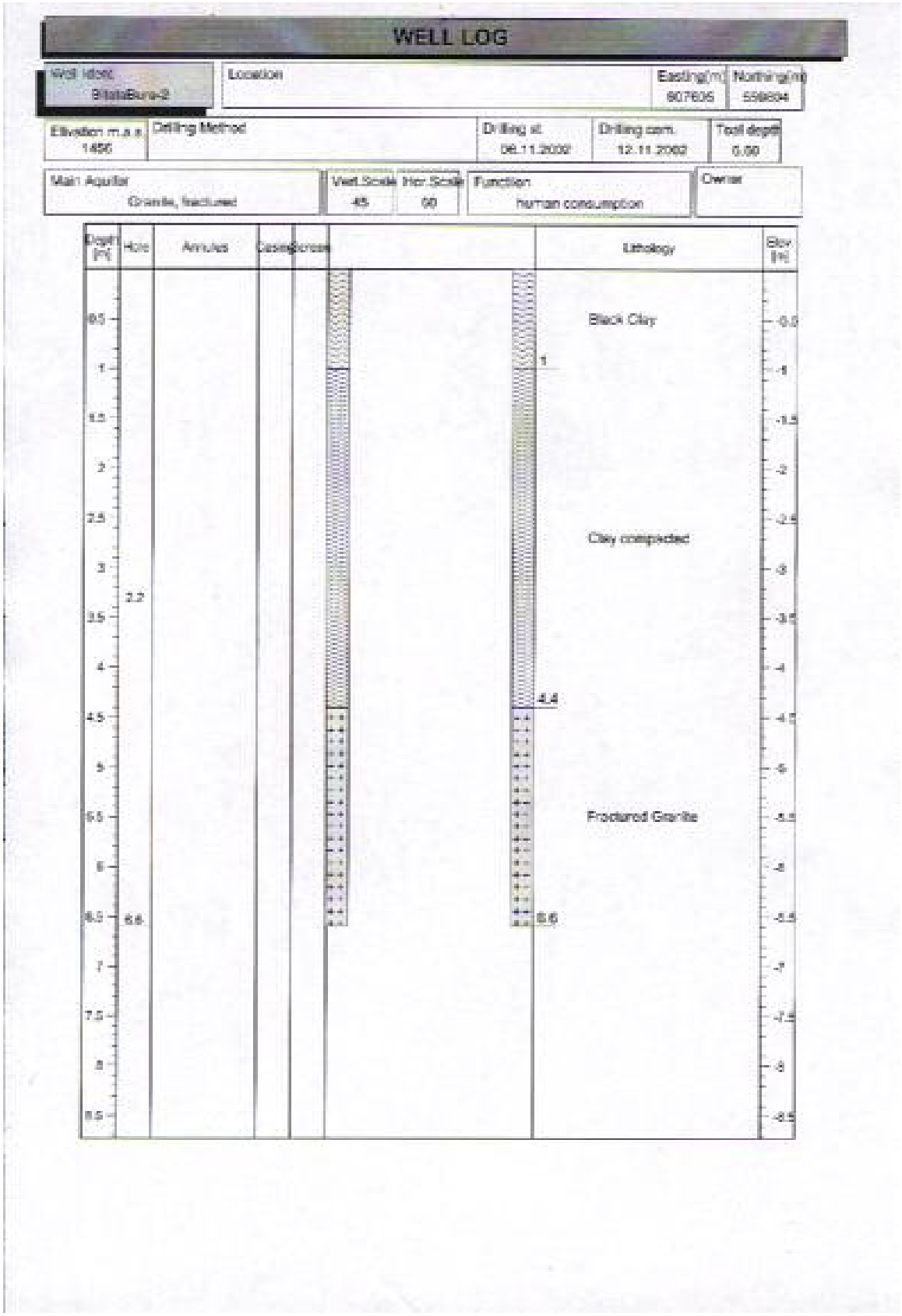
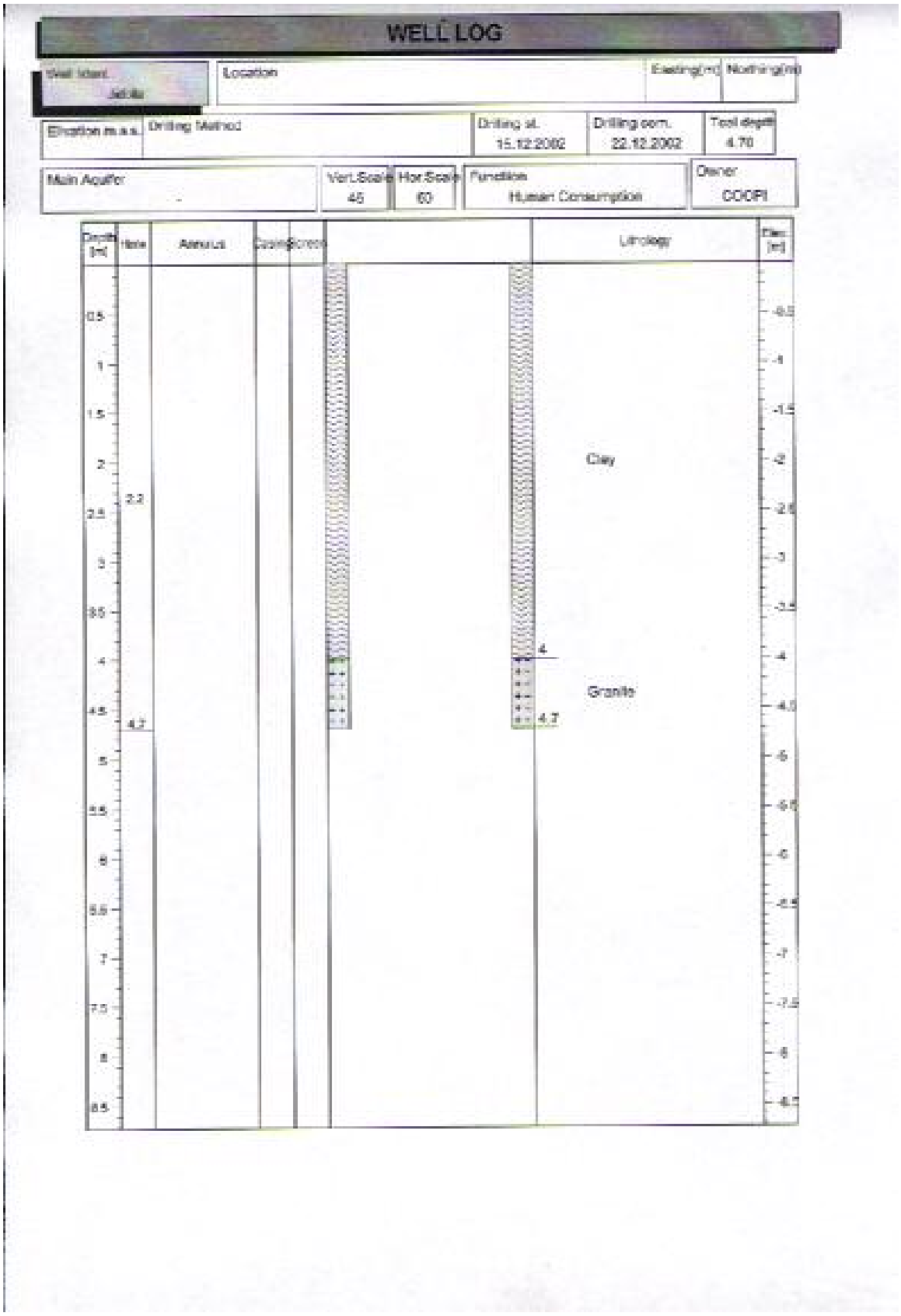
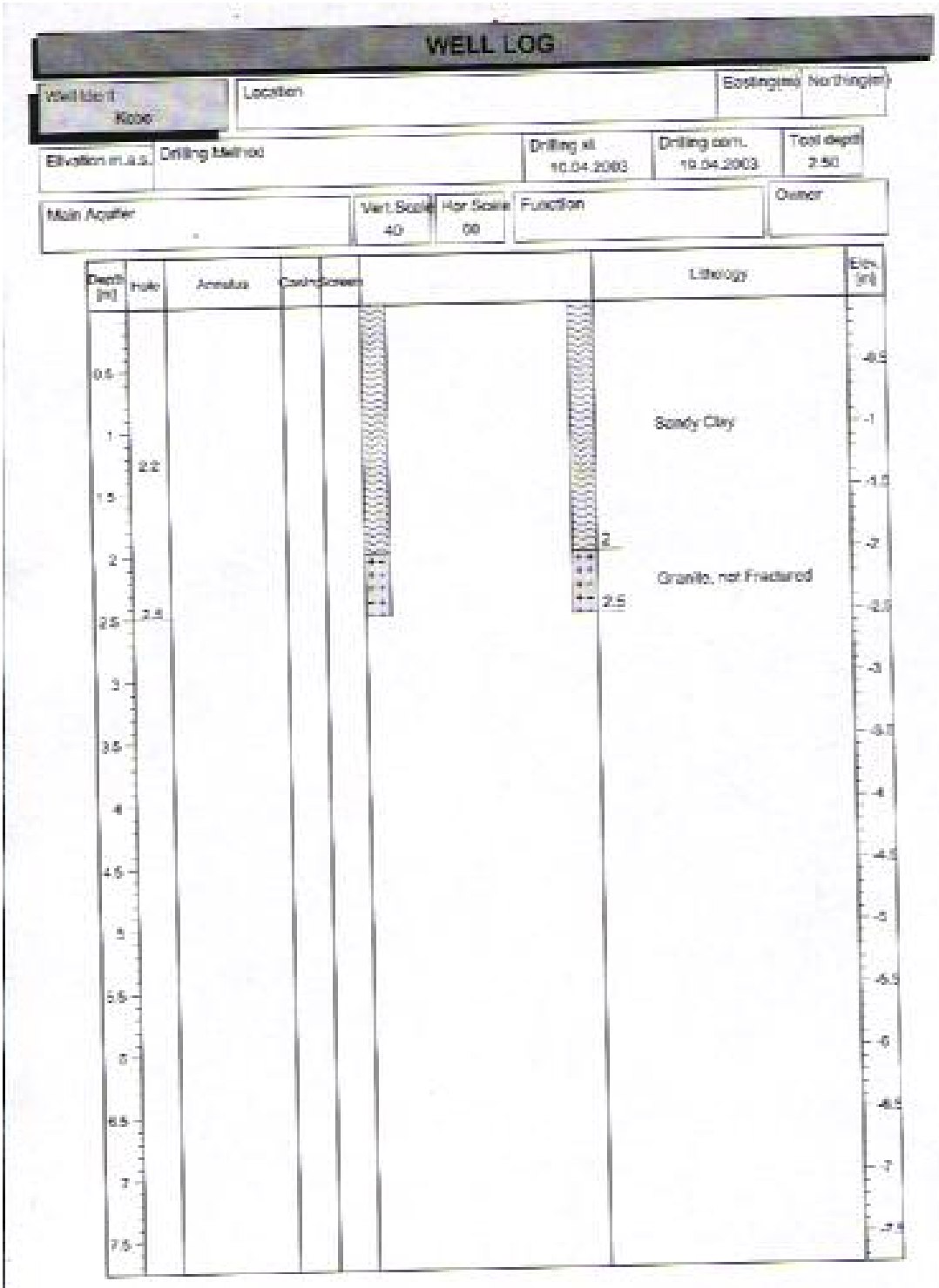
Well Ident
Location
Easting(m)
Northing(m)
Elevation m.a.s.l.
1456
Drilling Method
Drilling st.
Drilling com.
Total depth
7.00
Main Aquifer
Vert.Scale
45
Hor.Scale
60
Function
Human consumption
Owner
Depth (m)
Hole
Ann.Mat.
Casing/Screen
Lithology
Elev (m)
Grey colored clay
1.6
Compacted clay, light grey colored
2.2
5.25
Granite
7


WELL LOG
Well Idnt.
BilisiBura-2
Location
Easting(m)
607635
Northing(m)
Elevation m.a.s.l.
1450
Drilling Method
Drilling st.
06.11.2002
Drilling com.
12.11.2002
Tool depth
0.00
Main Aquifer
Granite, fractured
Vert.Scale
45
Hor.Scale
60
Function
human consumption
Owner
Depth [m]
Hole
Annulus
Casing
Screen
Lithology
Elev [m]
Black Clay
Clay compacted
Fractured Granite
2.2
4.4
6.6
1


WELL LOG
Location
Drilling st.
15.12.2002
Drilling com.
22.12.2002
Main Aquifer
Vert.Scale
45
Hor.Scale
60
Function
Human Consumption
Owner
COOPI
Depth [m]
Litrology
Clay
Granite
4
4.7
2.2


WELL LOG
Well Mark
Kobe
Location
Easting(m)
Northing(m)
Elevation m.a.s.l.
Drilling Method
Drilling st.
10.04.2003
Drilling com.
10.04.2003
Total depth
2.50
Main Aquifer
Vert. Scale
40
Hor Scale
00
Function
Owner
Depth [m]
Hole
Annulus
Casing
Screen
Lithology
Elev. [m]
Sandy Clay
Granite, not Fractured
2.2
2.4
2
2.5

Conclusion

Water plays vital roll in the development endeavors of mankind and the shortage of water affects directly or indirectly the livelihoods of communities. The shortage of potable water supply is greatly affecting the communities of Liben since a limited number of well existing for the rural community

The newly constructed eleven water wells constructed for the rural community believed to alleviate the problems of the respective communities significantly, since the numbers of beneficiaries from the new wells are more than nine thousand.

As shown inside the report, the depths of the wells are in the ranges between 4.5m and 15m. The productivity of the wells is more than sufficient to be pumped by the respective submersible and hand pumps for ten hours duration per day. The quality of the water in most of the wells is good to be potable and the construction works use to protect the wells from surface pollution.

The general accomplishment of the project can be regarded as successful since the number of the dry wells are much less than the productive once. This indicates the degree of attention given for the exploration work before physical implementation of the project. It also indicates the potential of the area for shallow ground water development.

Annex 5: Negele Town Water Supply Report

COOPI
Drought consequence Alleviation Project in Borena zone

Technical Report of Negele Water Supply Rehabilitation Project

August, 2003
Negele Borena

Table of Contents

Preface

Technical reports are very important for managing of the newly constructed schemes, since it is the lonely formal way of preserving the construction history of the schemes. Usually technical reports consist of the duration and the kinds of works were accomplished. It is recommendable to refer the reports before planning any activities related with maintenance, upgrading or expansion works on every scheme.

This technical report consists of the general physical and non physical activities accomplished to rehabilitate the abandoned water wells of Negele, which are located at the back of Red Cross office of Negele, and the newly set pipe line connection with the town water supply system. In addition it also includes the general findings regarding the aquifer potential of the area and the exploitation rate fixed at current.

Pictures, maps and charts as well as raw pumping test data are also included in the report to make it more elaborative. Thus the report can be use as a reference for any activity regarding the rehabilitated scheme.

Thank you,

Getachew Alefe
COOPI-Negele Office
August, 2003

1 Introduction

1-1 Back ground Of the project

COOPI has been working on different development sectors since several years ago in the past. water sector has been one of the main sector of intervention for COOPI, and still the organization is actively participating in the alleviation of the stress imposed on the community as result shortage of potable water sources.

Recently the organization formulated a project under head title of 'Drought Consequences Alleviation in Borena Zone', which targeted on the alleviation of the problems that could happen after the drought period of 2001/2002.

The main frame work of the project comprises the construction of ten hand-dug wells equipped with hand-pumps and other two hand-dug wells equipped with solar power driven submersible pumps. The water wells are located in the places either where the availability of potable water sources are not the existing at all or in the places located far from the existing water sources.

In addition to the construction of hand dug wells for rural community, Negele town water supply improvement work was also included in the main frame work of the project under sub title 'Negele Town Water Supply Rehabilitation Work', since the drought also affected directly and/or indirectly the water supply system of town. The direct effect of the drought on the water supply of the town mainly revel by decreasing the amount of water that has get in to the dam, which currently serving as the ultimate source of water for the town distribution.

The indirect effect of the drought can be related with miss using of the dam water and related grazing activity around the dam. As already seen, the surrounding residents use the dam as source of water for watering there domestic animals when the other water sources dry out during elongated dry season. In fact this activity not only reduce the amount of water by extra exploiting the dam, but also it caused deterioration of the natural ecosystem in the surrounding as well as in the up stream of the dam. This phenomenon triggered the accumulation of silt into the dam beyond the expectation.

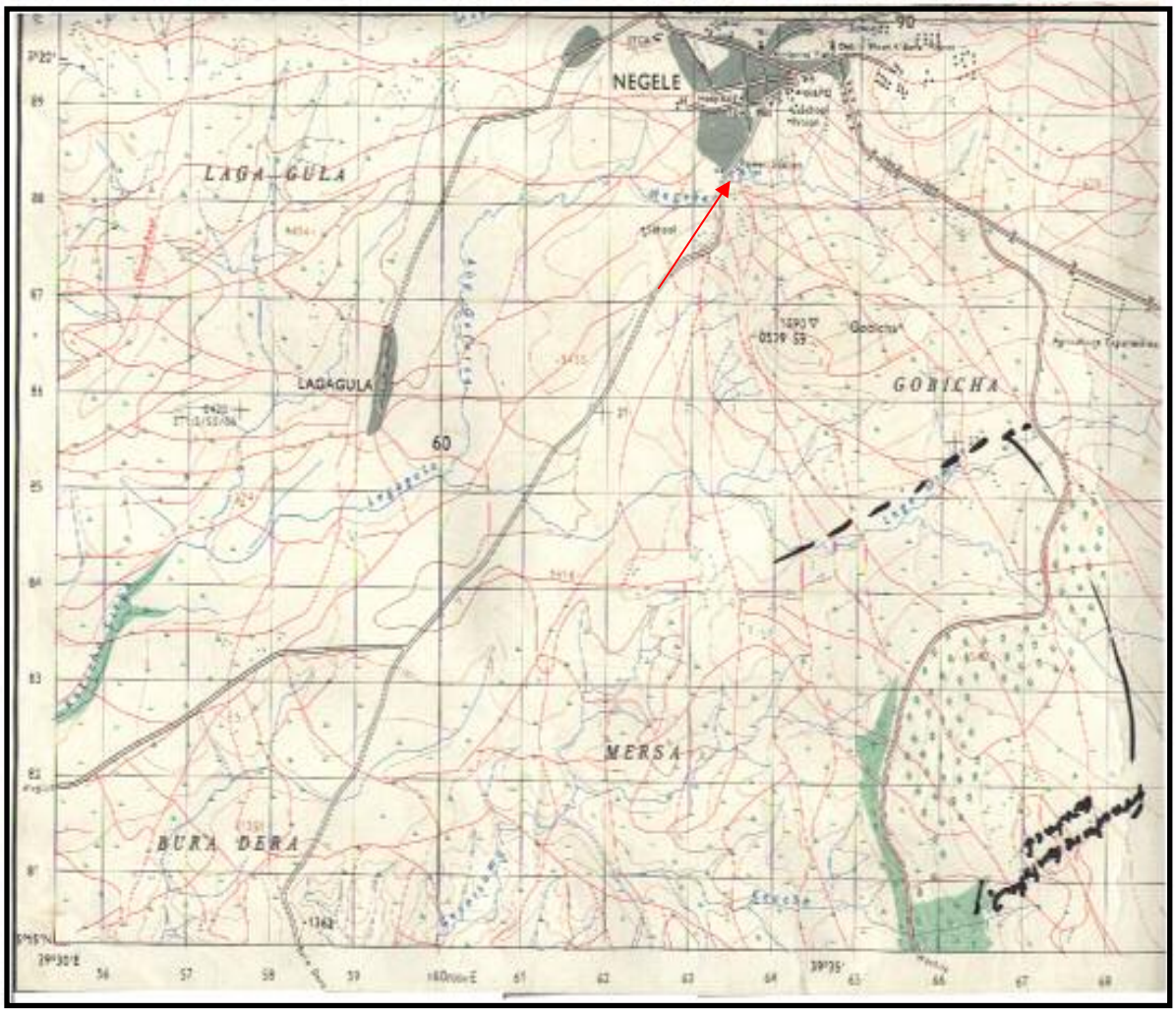
For these and other un described reasons, the efficiency of the dam is highly reduced so as affected the town water distribution system. To alleviate the problem, augmentation of the raw water supply to the treatment plant from other sources proposed by the then BZWMERDD i.e. rehabilitation of the already abandoned hand dug wells around the town and making a connection with the treatment plant.

The initial project proposal and pre feasibility study was done jointly by COOPI and BZWMERDD. Following the feasibility study, COOPI preceded on the implementation of the project by the fund secured from USAID-OFDA.

1-2 The project location

Negele is the capital of Gujii zone of Oromia National Regional state. The town appears by south west of Addiss Abeba at the distance of 595Km.It is accessible partly by standard asphalt road and partly by all whether gravel road. The intervention area extends from the southern to south eastern part of the town.

Map-1 Location map of the intervention area
Adapted from 1:50,000 topographic map
Of Negele Borena sheet
Sheet 0539D1



1-3 Anatomy Of The Project

The main frame work of the project includes

- Rehabilitation of the hand dug wells.
- Rehabilitation of the reservoir and construction of pump house.
- Rehabilitation of power line.
- Pipe laying.
- Installation of submersible and surface pumps.

1-4 Main Activities Accomplished.

Non physical and physical works were accomplished: by non physical it means that those works related with the overall un tangible works but very important in the justification of the out came of the project as well as planning the project implementation, where as by physical it means that those works related with the construction and others.

The following listed activities can able to describe the whole physical and non physical works accomplished during the project implementation.

- Understanding of the exact situation of the wells, condition of the reservoir, pump house as well as the well field in order to plan the maximum efficient way of rehabilitation.
- Construction works and rehabilitation works in the actual well fields.
- Maintenance of the reservoir and construction of new pump house.
- Visualizing the route of the pipe line.
- Setting of pumps, pipe laying and related works.
- Describing the power line problem.
- Setting of new power line and related works.
- Final evaluation of the wells' performance and productivity.

2- Rehabilitation of Wells

2-1 General History of the Wells and Condition of the Wells

In the past several years ago Negele water supply service had been using three boreholes and additional hand dug well to supply the urban community with potable water.

All the borehole and hand dug well are spread along Negele streamline. The three boreholes, which are named, by BH1 BH2 and BH3 are linearly locate along the stream bank with average separation of 300m. The depth of the wells ranges from 92.2m to 104m (i.e. BH1 = 98, BH2 = 104,BH3=92.1) and the yield from the boreholes were 0.6, 3.1 and 0.76 litter per second for BH1, BH2 and BH3, respectively.

In order to augment the boreholes another expansion work had done in 1978 E.C by some Chinese company. The expansion includes excavating hand-dug wells, laying additional pipeline, and construction of public fountains. The hand dug wells are five in number and clustery located just at the back of Red Cross compound, along the same stream line to that of boreholes, near to BH3. No data available regarding the original design and construction history of the wells, but some documentations from NWS show that all are series interconnected by channel and the pumping had been done from main well (here in after referred as well number three).

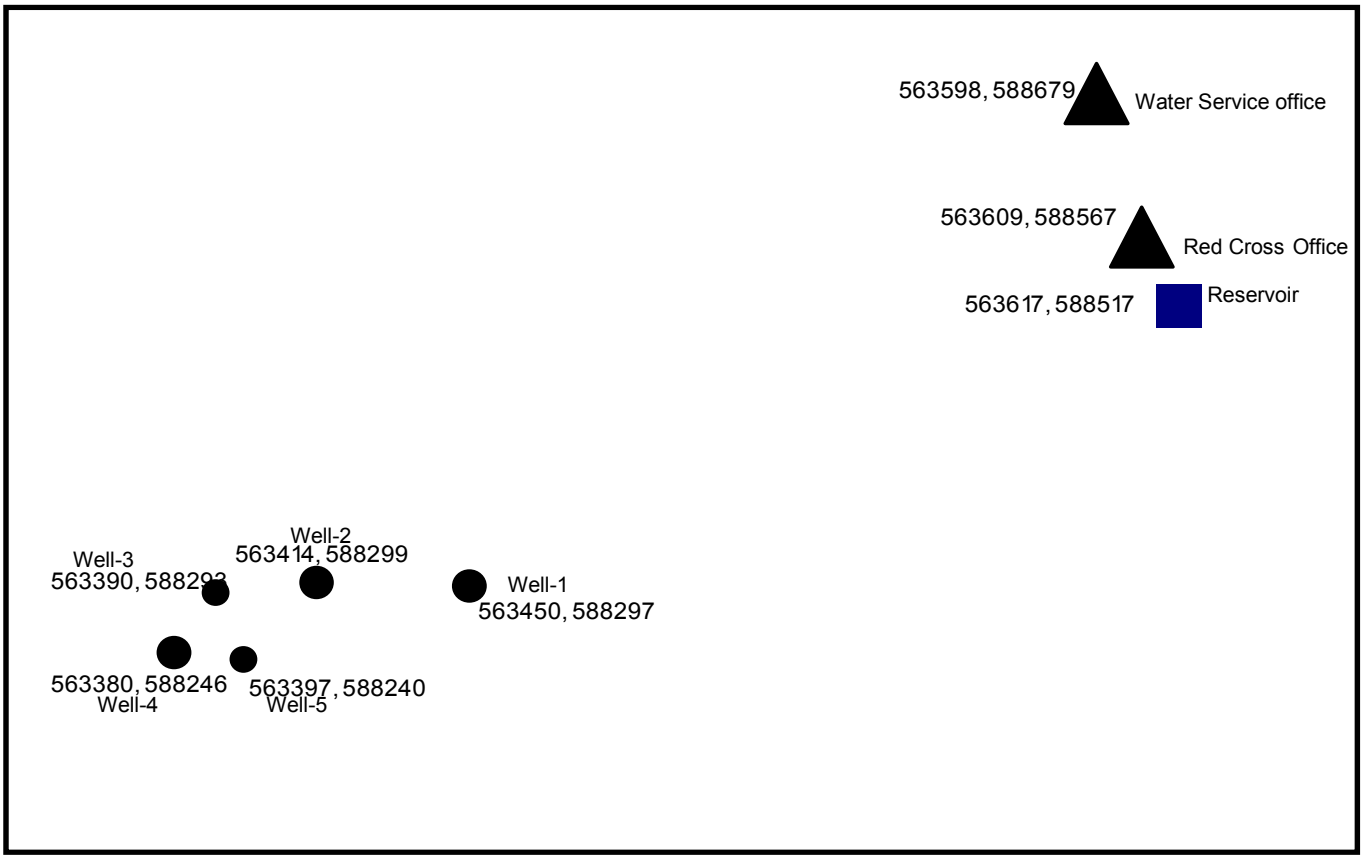
Well three serves as collecting well and has a diameter of 2.90m, with depth of 12m. The static water level at well one was 3.40m. Some documented informal pumping test results show that the well has only 60cm drown dawn with pumping rate of 5.5 lit/sec for 1.35 hrs pumping duration. Also the well drown dawn further go up to 1.20m or 1.30m during pumping at dry season with pumping rate of 8lit/sce or 8.1 lit/sec for duration of 21/2 hours.

According to some oral information from the elders, the hand dug well were been concrete slab covered but now they are left opened because of robbery act in search of the reinforcement iron bard and junipers wooden bar. (***Note*** the hand-dug wells were abandoned before the rehabilitation work). No technical data available regarding the construction history of the other four wells and also no data available regarding the construction history of the channel which interconnected the wells.

Regarding tasks, the water from both boreholes and hand dug well first will be pumped to the reservoir located in the compound of Red Cross and after it once again will be pumped to the other reservoir, located near to the church, through pressure main pipe that already connected with distribution net work. This shows that the pressure main and the distribution line was the same.

The physical work started by pumping the wells and dries them up for physical observation of the sub structures, since the accumulation of the water in the vicinity hindered the physical observation of the inside part of the wells.

BH- Borehole
NWS- Negel Town Water Supply Service



Map2- Relative position of the wells, reservoir and offices with geographic coordinates in UTM (east, north) in meter)

2-2 Wells Rehabilitation Work

First the wells had been pumped for several hours till the water level appear near to the bottom of the wells so as to observe the original characteristics of the wells. From this the following facts were observed.

- Initially it was believed that the wells cased by concrete rings, However they were not. The wells were simply excavated with telescopic fashion and masonry wall were build on the upper part of each wells in order to prevent the collapsing of loosen formation. As observed the condition of the retaining wall of the wells is not as such bad. It is easily maintainable with additional reinforcement work.
- The connection channels are identified and the channel was 40cm wide open masonry channel which extends up to the retaining masonry wall.
- Since the wells left open, high amount of waste materials: composed of dead animals body, woods, plant folio and dust, deposited in each well. i.e. significantly reduced the depths' of the wells.
- As observed during the pumping of the water, the productivity of the wells is significantly increased as compare with the initial documented well test result. In Fact, the draw dawn observed in the other wells while the

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Ac- Alternative current

pumping was running in well one shows the inter connection channels were in good condition.

On the basis of the pre mentioned observations it was suggested the well rehabilitation work to proceed step by step according to the following procedure.

I. Clearing of the wells from not indigenous Materials.
II. Maintain the retaining well.
III. Constructing superficial structures.

I. Clearing of the wells from not indigenous Materials.

Fig-1 the topographic leveling work was carried out to prevent flooding

In the beginning the clearing was started only by focusing on well-1 and well-2, since the amount of water in overall the wells is too high to pump out all simultaneously. Thus the clearing work had been proceeding from August, 2002 to December, 2003. Beside the well clearing work topographic leveling work had been accomplished in the surrounding of the wells in order to prevent the concentration of the run off that might flood the wells. The leveling work was accomplished by cutting and filling, and it covers an area 75m X50m.

Fig-2 the wells were full of indigenous materials.

It was not possible to clear the other three wells simultaneously with the first two wells because of the necessity of big capacity pumps that able to drop dawn the water level of the area significantly and because of the swampy nature of the terrain.

To eradicate the swamp around the wells two drainage ditches of length 45m and 60m were constructed along the main stream line that pass though the well field. As result the terrain becomes dry so we were able to work on the rest of three wells. Moreover we were able to clear the rest of the wells by using high capacity pumps.

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Ac- Alternative current

Fig-3 peoples clearing the well, while pumping was on progress

For comparison the initial internal status of the wells and the final appearance of the wells after clearing work are presented in the following table.

Before	*After*
1. *Full of non indigenous material such as dead animal bodies, plant folio, plastics, woods and clay.* 2. *The water appears very green because of Algae and other aquatic floras and faunas.* 3. *depth of the wells observed before clearing work* ➢ *Well one – 1.50m* ➢ *Well two- 4.60m* ➢ *Well three- 7.00m* ➢ *Well four- 3.00m* ➢ *Well five- 4.00m*	1. **The wells become out of all the mentioned matters.** 2. **The water appears colorless with no aquatic faunas and flor**as. 3. **depth of the wells observed after clearing work** ➢ Well one- 6.80m ➢ Well two- 6.77m ➢ Well three- 7.40m ➢ Well four- 4.50m ➢ Well five- 5.30m below ground level

Table-1 General clearing work summery

II. Maintain the retain wall

Rehabilitation of the wells by lowering concrete rings in to all the five wells was the first idea, but the idea dropout, because it could reduce the productivity of the well as result of artificially induced well-lose. The second idea was to maintain the retention wall of the wells and leave the wells as open wells (with out casing). This idea accepted by the respective expertise from the Zonal office of Water Resource and the rehabilitation work proceeded accordingly. The reasons for this are:

Fig-4 Initial condition of the retaining wall

- The condition of the existing retention wall is not bad, indicating that with further maintenance it can be sustainable for long time.
- As usual, the need of lowering the rings is to prevent collapsing and to create the open space between the internal part of the well and the wells' wall so as to pack the gravel in the annular space that serve as physical filtering media. In our case there is no need of physically filtering the water because the row water physically looks less turbid. Moreover, the raw water is going to be pumped to the treatment plant where it can have proper water treatment.

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- The third factor is related with the efficiency of the wells. Basically putting artificial material in to the well cause turbulence flow of water around the wells. This turbulence flow in to the well may cause some loss in well efficiency by imposing well loss. The higher the well-lose mean that the well couldn't produce as much water as the aquifer can sustain.
- The part of the well that originally left open was not yet collapsed mean that not liable for collapsing.

Based on the above factor the rehabilitation of the internal part of the wells proceeded by clearing and plastering of the retention wall, leaving the bottom part of the well as it were. The plastering was done to make the wall not favorable to the root system of aquatic floras.

III. Constructing Wells' head.

The rehabilitation of the internal part of wells was followed by the construction of the wells head. The well head constructed to protect the wells from the seasonal stream flooding and to protect the well from waste material that can get in to the well.

Fig-5 I- the previous not covered circular wells head II- the new rectangular wells head with top slab cover

The well head construction work includes disrupting of the previous un proper (un covered) circular well heads and construction new rectangular masonry wall around the each well to sufficient height as well as covering the top by reinforced concrete slab with man hole.

3- Maintenance of the reservoir and construction of new pump house.

3-1 Maintenance of the reservoir

The reservoir is located in the compound of Red Cross. The capacity of the reservoir is 25m^3 and the outer part of the reservoir is rectangular, but it is conical in the inner part. The year of construction of the reservoir is not known, but possibly, it constructed together with that of the boreholes.

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Fig-6 The outlook of the reservoir from the front side

As compare to the other structures, the reservoir is not very much affected. The part the reservoir that needs rehabilitation is:

- The in side and outside wall.
- The wash out.
- The cover of Manhole.

The side wall has cracks which can be maintained by chiseling and plastering. Therefore, the work had been done by chiseling and plastering of the wall in the internal part. The outer wall of the reservoir is also maintained by coarse plastering.

The wash out that made of GI pipe was broken at the inner bottom part of the reservoir because of corrosion. There was an attempt to maintain it by replacing with another pipe by chiseling and pulling out from the broken point. However, chisel in to deep body of the reservoir though to cause serious damage on the foundation. Rather we preferred chisel up to 30 cm deep in to the wall and fixed it by mortar after replacing the old pipe by the new one. In order to control the leakage fully, flat iron with paint of anti-rest fixed from the inner part the reservoir by removable bolt and nut. The manhole covered by iron sheet of size 0.81m*0.81m.

3-2 Construction new pumping House

The former pumping house was build in attach with the back side of the reservoir. It was constructed by wooden wall and iron sheet roof. The house had two classes: the pump house and the store. It was almost completely destroyed; mean that not at the maintainable condition. Thus construction of new pumping house proposed in the place where the previous house lay on.

Fig-7 the new pump house constructed in attached with the reservoir

Accordingly, new house constructed with cement block wall and iron sheet roof. As the previous one, the house has two classes in which first serve as the pumping room while the other for storing necessary materials. The house totally lay on the area of 15.525m^2 and the internal wall painted by white color. Two iron doors of size 1.2mX2m and 1mX2m are fixed on the respective pumping and store houses. Beside two 0.60cmX0.50cm windows are opened in the pumping house for aeration.

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4- Pipe laying and setting of Pumps.

4-1 Pipe lying

The pipe laying work includes:

- Designing the route of the line.
- The excavation of the trenches.
- Laying pipes and fixing of the necessary fittings at the necessary places.
- Refilling the trenches.

4-1-a Designing the route of the pipe line.

It is the usual way to make the route survey in order to identify the possible way of pipe line that could minimize the pipe line length with minimum effect on any others structures both existing at the present and going to be set in future. The first idea of the main pipe line route that connect the reservoir to the water treatment plant was to follow the bank of the stream to wards the dam then to turn to the reservoir through the compound of Water Office. However; the idea refused by the Zonal Water Office, since the line cross open field, that could be residential area in future. The master plan of Negele town also confirm the expectation of the Water Office, but do not indicate the future possible way of inter connecting road.

The other reason for redesigning of the pipe line route is that initially the route thought to be end up at the inlet of the treatment plant (At the gravel filter pan), However, the water service office, who manage the treatment plant, suggested that no need of filtering the water from the well through the gravel filter pan that use to treat the row water from the dam at early stage. It was suggested to bypass the gravel filter In order to go directly to the next filtering unit i.e. sand filter or else to the wet well where the water treated by chlorination for bacteriological disinfection.

For the indicated reason the design of the pie line route changed, and the new design followed the existing abandoned pipe line up some point in side the Nursery compound through ELPA power generator compound. Then after it follow the existing interconnection road towards the north of the dam. The line once again turns to the north and reaches the water treatment plant compound after crossing the compound of Negele Water Service Office. Finally inside the treatment plant the line follow the northern edge of the gravel filter unit and at the end of the gravel filter unit two lines are taken out: one directly to the wet well while the other to end up at gravel filter where water flows by gravity to the next sand filter.

4-1-b The excavation of the trench

The main (it named main trench to differ it from the trench for power line) trench excavation work had been carried out manually, and the dimension of the trench excavation decided based on the suggestion from the Water Department expertise. The width of the trench was 0.6m trough out the route, and the depth was 0.9 m below the ground level. However, the depth of the trench reduced to 0.60m because of massive rock layer encountered along the route from the near by of the dam to the north end of Water Service Office compound. Beside, in the compound of the Power Generator Plant of ELPA we encountered outcropped massive granite rock layer and the layer totally not possible to crush, thus the pipe line left bare on the surface for some 25m.

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Fig-8 workers at the trench excavation work

The other trench excavation work includes the route from the main well to the reservoir for the main pressure pipe line. Like the other trench dimension of the trench is: 0.90m deep and 0.60m wide.

The over all length of the trench is 1625.51m and from the total length 1492.8 m is from the reservoir to the treatment plant and the rest 132.8m is from the main well to the reservoir.

4-1-c Pipe laying

Galvanized iron pipes of gage 2 are used for the pipe line. The size of the pipes is 2 1/2 inch for the whole route, i.e. from the well to reservoir and from the reservoir to the treatment plant. To asset the line around 280 pieces or 1680m long pipe used. The direct line length of the pipe line is 1625.5m but the difference 54.5 m long pipe used to join the line with the pumping house, to cut and join with the fittings in place where the length of each pipe is exceeding the trench, to asset the submersible pump into the well, to asset the inlet of the reservoir as well as the inlets in the treatment plant and e.t.c.

Fig-9 manholes with concrete slab cover constructed in seven places where they are necessary

Necessary fittings such as Elbows, Joints, Get valves and Check valves are fixed with the line according to there necessity. Elbows are used in every point to create 900 turning and Joints are used to make the line easy to dismantle during maintenance. Get valves are fixed in seven places along the route to the treatment plant from the reservoir, to control the back flow of water in case when needed to maintain the line and masonry manholes with size of 0.8m by 0.8m constructed on the places where Get valves are fixed.

The manholes are covered from the top by movable concrete slab cover. Two Check Valves are fixed in the near by of the outlets, from the respective two pumps so as to hinder the back flow of water. In addition, two Water Counters are fixed near the outlets of the pumps to manage the production of water in required specific period of time.

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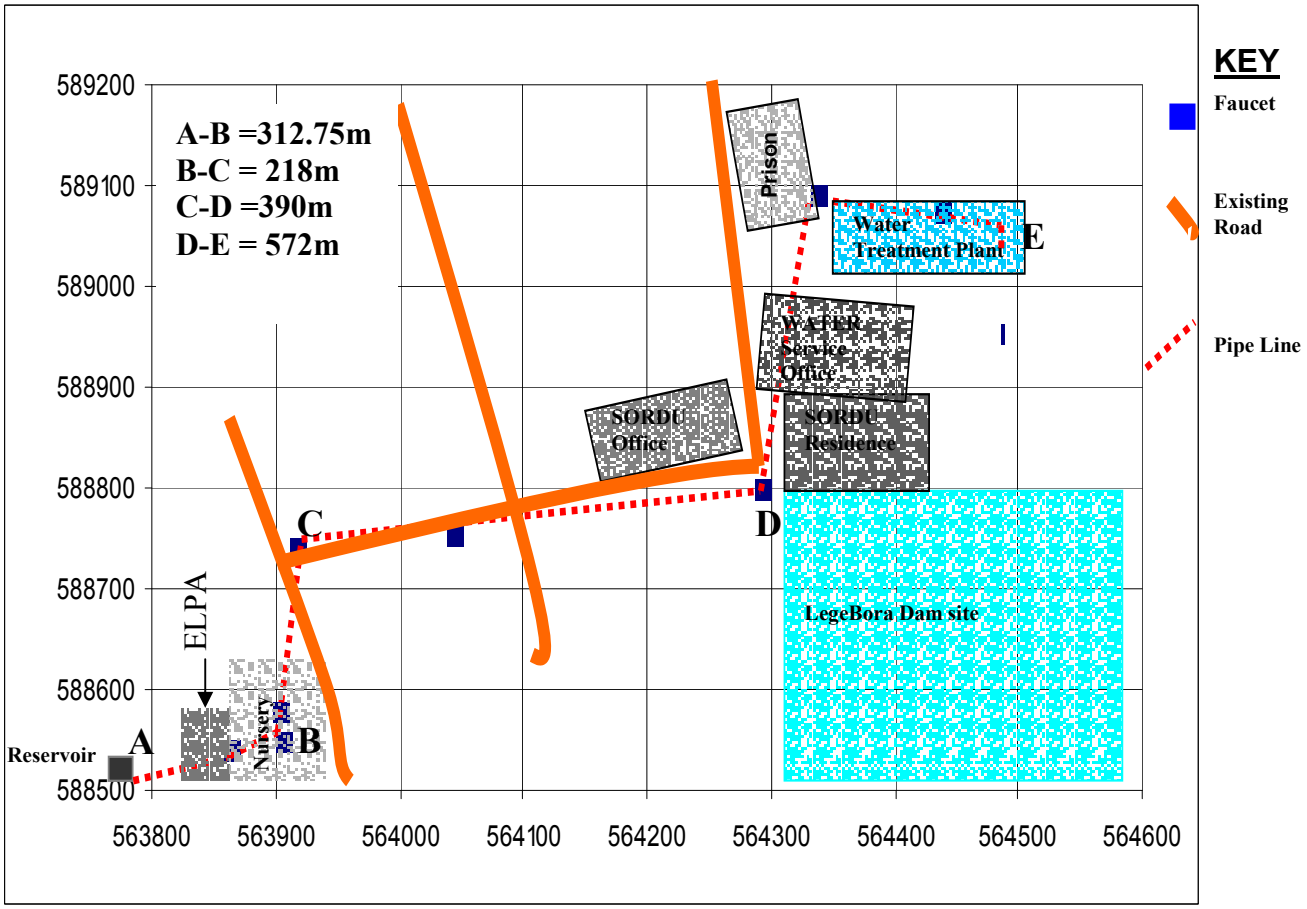

Map-3 The sketch of pipe line route, note not on to scale

4-1-d Refilling of the trench

The refilling of the pipe line trench was executed after the necessary test on the pipe line for the pressure. The pressure test was done to identify and to manage places where there is leakage as result of pumping pressure. After the test the trench was refilled in a way to maintain the previous topographic level. Crushed stones are used in places where the traffic is high and could damage the pipe line because of the load.

4-2 Installation of pumps

Two different kinds of pumps are installed to pump the water to the treatment plant from the wells. The first one is Ac electric power driven submersible pump and the other is Disel Engine driven Surface pump.

4-2-a Submersible pump

Submersible pump installed on the well three (well-3) to pump water from the well to the reservoir. Seven meters long 2 1/2 inch size Galvanized pipe used as suction pipe for the

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submersible pump and the outer rim of the suction pipe welded to sheet metal on top to support the weight of the pump.

Fig-10 the submersible pump installed on well number three with water counter.

Water level control electrodes are also lowered in the well with submersible pump in order to control the water level and to protect the pump from dry running. The pump finally connected with the power line through the compatible electric power control board and the characteristics of the pump is:

- Brand- 6" NR-151
- Model- NR 151-A/28
- Made in- Italy
- Discharge
- Power Hp 12.5
  Kw 9

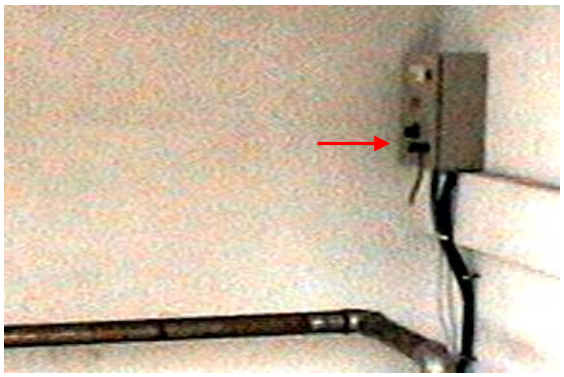

Fig-11 the electric control switch board for the submersible pump installed inside the main pump house.

During the test, after the final installation of the pump, the pump can deliver 4.72 liters of water per second with existing head difference between the water level inside the well and the reservoir inlet.

4-2-b Surface pump (Booster pump)

The surface pump is Diesel Engine driven pump installed inside the main pumping house. The pump use to suck water from the reservoir and to pump to the water treatment plant.

Fig-12 the surface pump installed inside the pump house.

The pump mantled on the reinforced concrete slab of size 0.60m by 1.45m and by 20cm high, which constructed inside the main pumping house. It is connected with the reservoir through existing outlet by 2 1/2 inch galvanized iron pipe. The characteristics of the pump are listed below:

- Brand- Lombardini
- Model
- Hp
- RPM
- Efficiency

The actual delivery capacity of the pump at the treatment plant tested to be 16.5 m^3 per hour that is 4.5 liters per second.

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5- Rehabilitation of power line.

Submersible pump is a kind of pump preferred to pump the water from the wells to the reservoir. Mostly Submersible pumps use AC electric power driven, and previously the Water Service Office also had been using Submersible pump to pump water from the same well with power supply from the town power supply net work of ELPA. However, currently the power line which the water Service Office had been using is more or less destroyed, and it is in a condition that not possible to maintain.

Fig-13 Partial view of the previous power line.

- The line supporting poles are hallowed by termites.
- The cables are broken and partly lost.
- Because of the corrosion, the conductivity of the cables is significantly reduced.
- Some Electrical fittings such as Insulators are missing

Because of the above and other reasons it was preferred to set new line rather than rehabilitating the old one. The a setting of the new power line started by consulting the respective expertise from ELPA-Negele office and the expertise suggested the line to be set underground rather than aerial because of the following reasons:

- Unavailability of treated woods, that is very basic to hold the cable above ground surface, in the normal markets of the country.
- Unavailability of electrical fittings that can withstand the power required by the pump, in the normal markets.
- Easy liability of Arial lines for damage.
- The availability of the underground electrical materials in the normal market.
- The Durability of the underground lines as well as lesser liability for damage.
- The easiness of the under ground lines to set.

Based on the suggestion from the respective expertise the line set under ground. PET electric cable of size 35mm/4mm used. The line prolong from the Water Service Office to the pump house, where the electric control switch board installed, through the compound of RED Cross Negele office. Then after the line go to the main well (well-three) where the Submersible pump installed. The over all length of the line along the route is 306m, and the line buried in the trench, which excavated priory, with depth of 1m below ground level. After all, the line connected with the existing power line switch of Water Service Office.

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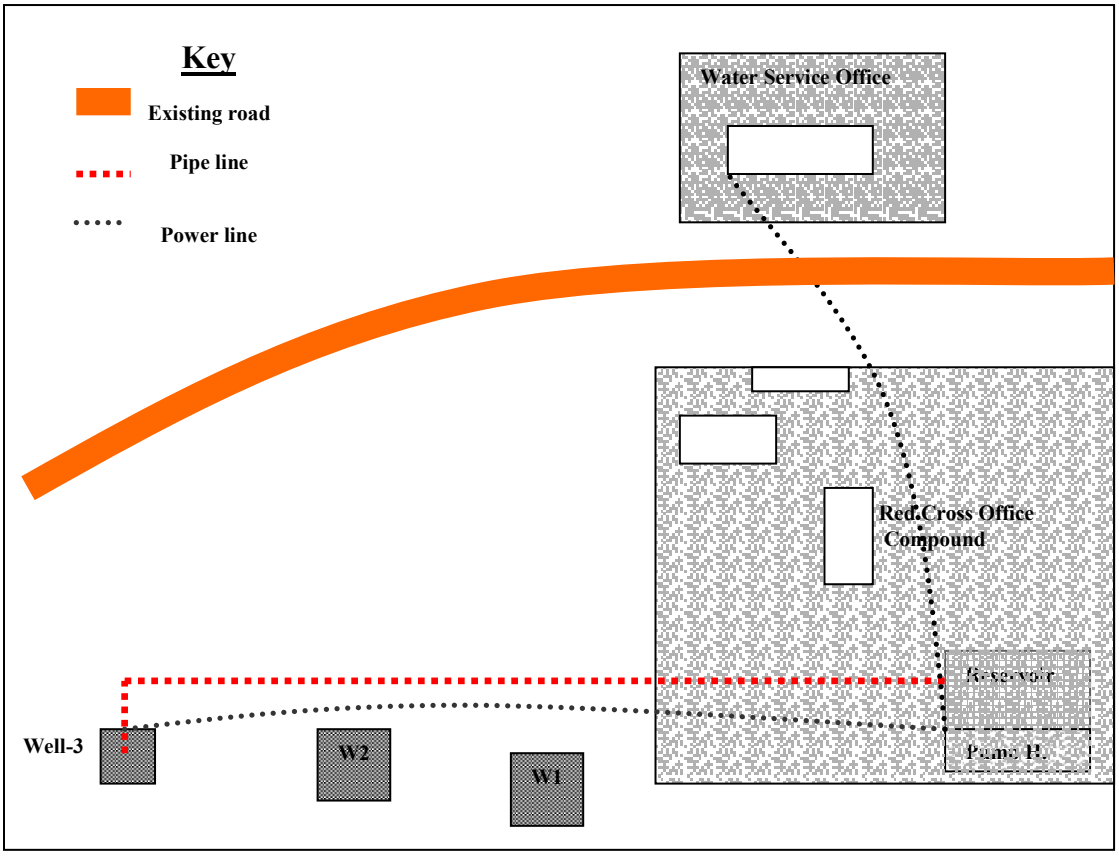

Map-4 The route of Power line and the pie line from the well to the reservioure

6- Evaluation of the well performance and productivity.

6-1 Data acquisition

The well performance and productivity can be determined by conducting proper pumping with the recovery test. Pumping test is a critical task where very important information and date can be collected regarding the over all productivity of the aquifer in the given area. The pumping test though to follow generally from provisional test to step draw dawn test and then to constant discharge test with recovery test.

The provisional test is usually done to estimate the possible discharge of the well while the step draw dawn test use for the evaluation of the parameters related with the well efficiency and well loss. Usually both tests are help full for newly constructed wells, but here we adapted constant discharge test and recovery test for evaluation of the wells, since the productivity of the wells already estimated during the pumping while construction work was on going.

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Constant discharge pumping test is very help full to determine:

- Sustainable abstraction rate
- The aquifer parameters.
- Physical limitation of the aquifer.

Recovery tests are important mainly to confirm the result of an aquifer parameters determined by the constant discharge test.

The test were carried out starting from July 18, 2003 to july19,2003 and the general in formation regarding the test is presented in the table below.

Well name	Negele hand dug well (well-3)	SWL	1.88m below ground level
Position		Test duration	1380min
	East 563390m	Test type	Constant discharge and recovery Test.
	North 588292m	Discharge	4.72 lit/sec
	Zone 37N		
Date	18-19/07/2003		
Pump type	submersible pump 10.5 KW		Discharge measured by the Known volume container.
Suction pipe	2 1/2" GI pipe		
Dis. Obv. Well.	21.6m		

During the test the water level is constantly recorded and the general trend of the pumping test data presented in the following chart.

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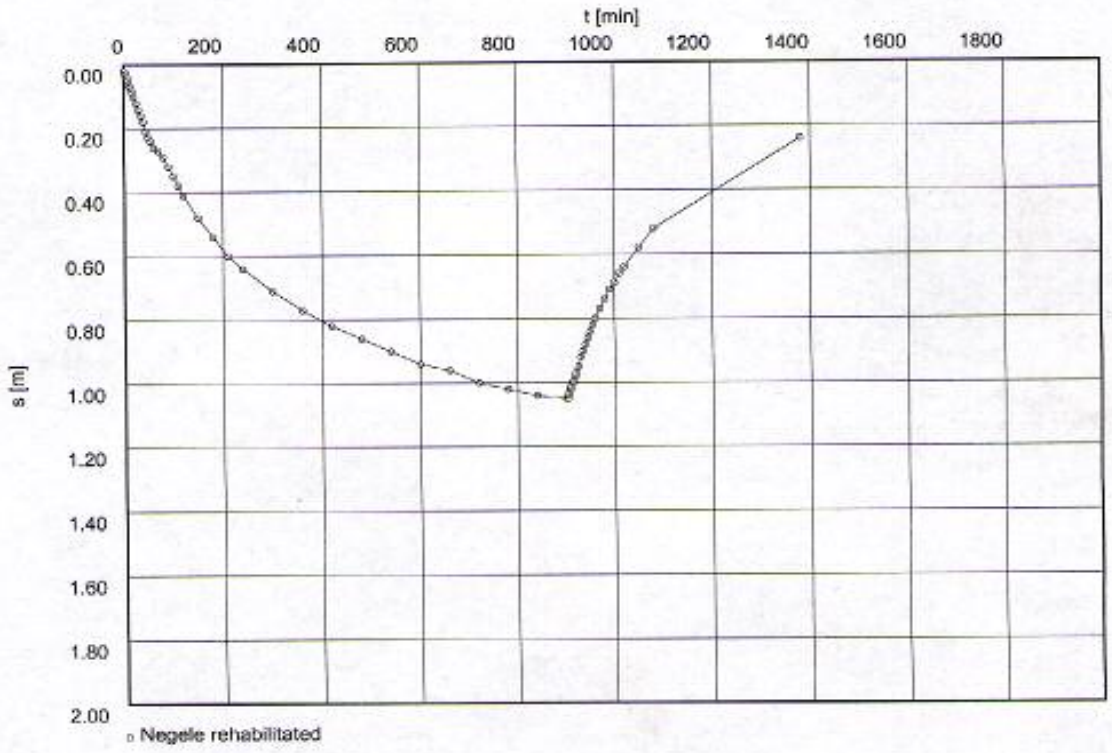
Waterloo Hydrogeologic 180 Columbia St. W. Waterloo,Ontario,Canada ph (519)746-1798	Pumping test analysis Time-Drawdown plot	Date: 22.07.2003	Page 1
		Project: USAID-OFDA funded	
		Evaluated by: Getachew Alefe	

Pumping Test No. 2	Test conducted on: 19.07.2003
three	
Discharge 4.72 l/s	



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6.2 Data analysis

Cooper and Jacob method applied for the data analysis in order to determine the aquifer parameters from measured draw dawn data with specified periods of time. The main parameters for description of aquifer are transmissivity and storativity and they are also the main variables in the well function.

For the calculation of aquifer parameters Cooper and Jacob assumes that:

- The aquifer is confined and has an ' apparent' infinite extent.
- The aquifer is homogeneous.
- The piezometric surface was horizontal prior to pumping
- The well is pumped at constant rate
- The well is fully penetrating.
- The well has no external recharge at the time of pumping and e.t.c.

Using the technique the transmissivity calculated to be 8.32 X 10^{-2} m^2/min and storativity 8.69 X 10^{-3}. Nearly similar figure obtained using Thiese and Jacob recovery test and the result obtained from the recovery test is 8.95 X 10^{-2} m^2/min. When we change the average of the two calculated transmissivity values in to per day unit it gives 124.34 m^2/day.

The calculated transmissivity and Storativity values can use in the general well equation that is:

- $\Delta s = Q X w(u)/4\pi T$
- $U = r^2S/4Tt$

Where

Δs is draw dawn in meter
Q discharge in m^3/day
W(u) well function as function of u
T transmissivity in m^2/day
t is time in days

Assume that the well can be pumped for continuous 18 hours, and the radial distance is 1m near the pumping well with the pump position is 7.2m below datum point. Using the assumption the maximum pumping rate should be not more than 1046m^3 or 12.1 lit/sec. If we assume the other factors remain and taking the safety factor to40%, 50% and 60%, the possible safe yield of the well is 4.84, 6.05, 7.26 with the respective safety factors.

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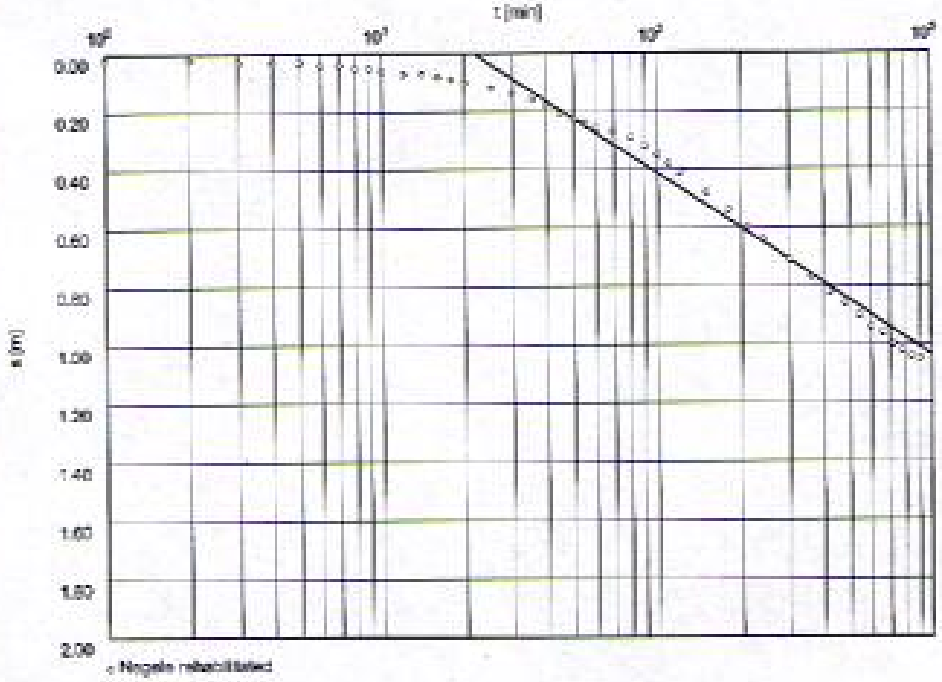
Waterloo Hydrogeologic 160 Columbia St. W. Waterloo,Ontario,Canada ph:(519)746-1798	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 22.07.2003 Page 1 Project: USAID-OFDA funded Evaluated by: Getachew Alelio
Pumping Test No. 2		Test conducted on: 19.07.2003
Rmax		
Discharge 4.72 l/s		



Transmissibility [m²/min]: 8.32 x 10⁻²

Storativity: 8.65 x 10⁻³

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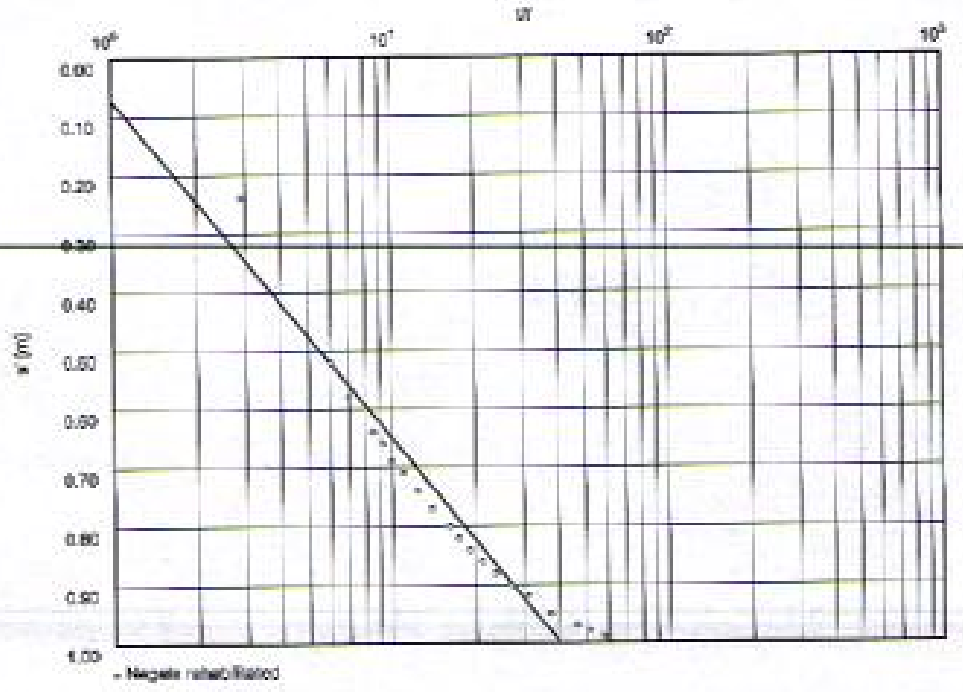
Waterloo Hydrogeologic
189 Columbia St. W
Waterloo, Ontario, Canada
ph.(519)746-1798

Pumping test analysis
Recovery method after
THEIS & JACOB
Confined aquifer

Date: 22.07.2003 | Page 1
Project: USAID-OFDA funded
Evaluated by: Getachew Abdo

Pumping Test No. 2 | Test conducted on: 19.07.2003
Theis
Discharge 4.72 l/s
Pumping test duration: 900.00 min



Transmissivity [m²/min]: 8.95 x 10⁻³

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Waterloo Hydrogeologic 160 Columbia St. W.	Pumping test analysis Time-Drawdown plot	Date: 22.07.2003	Page 2
		Project: USAID-OFDA funded	
		Evaluated by: Getachew Alefe	
Pumping Test No. 2		Test conducted on: 19.07.2003	
three		Negele rehabilitated hand dug well	
Discharge 4.72 l/s		Distance from the pumping well: 21.600 m	

Static water level: 1.880 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]
1	1.00	1.900	0.020
2	2.00	1.900	0.020
3	3.00	1.910	0.030
4	4.00	1.910	0.030
5	5.00	1.910	0.030
6	6.00	1.920	0.040
7	7.00	1.920	0.040
8	8.00	1.930	0.050
9	9.00	1.930	0.050
10	10.00	1.940	0.060
11	12.00	1.950	0.070
12	14.00	1.950	0.070
13	16.00	1.960	0.080
14	18.00	1.970	0.090
15	20.00	1.980	0.100
16	25.00	2.000	0.120
17	30.00	2.020	0.140
18	35.00	2.040	0.160
19	40.00	2.060	0.180
20	45.00	2.090	0.210
21	50.00	2.110	0.230
22	55.00	2.120	0.240
23	60.00	2.140	0.260
24	70.00	2.150	0.270
25	80.00	2.170	0.290
26	90.00	2.200	0.320
27	100.00	2.230	0.350
28	110.00	2.250	0.370
29	120.00	2.290	0.410
30	150.00	2.320	0.440
31	180.00	2.420	0.540
32	210.00	2.480	0.600
33	240.00	2.520	0.640
34	300.00	2.590	0.710
35	360.00	2.650	0.770
36	420.00	2.700	0.820
37	480.00	2.740	0.860
38	540.00	2.780	0.900
39	600.00	2.820	0.940
40	660.00	2.840	0.960
41	720.00	2.880	1.000
42	780.00	2.900	1.020
43	840.00	2.920	1.040
44	900.00	2.930	1.050
45	901.00	2.930	1.050
46	902.00	2.930	1.050
47	903.00	2.930	1.050
48	904.00	2.920	1.040
49	905.00	2.910	1.030
50	906.00	2.910	1.030

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Waterloo Hydrogeologic 160 Columbia St. W. Waterloo,Ontario,Canada ph (519)746-1798	Pumping test analysis Time-Drawdown plot	Date: 22.07.2003	Page 3
		Project: USAID-OFDA funded	
		Evaluated by: Getachew Alehe	

Pumping Test No: 2 — Test conducted on: 19.07.2003

three — Negelle rehabilitated hand dug well

Discharge 4.72 l/s — Distance from the pumping well 21.600 m

Static water level: 1.850 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]
51	907.00	2.900	1.050
52	908.00	2.900	1.050
53	909.00	2.900	1.050
54	910.00	2.890	1.040
55	912.00	2.880	1.030
56	914.00	2.880	1.030
57	916.00	2.870	0.990
58	918.00	2.880	0.980
59	920.00	2.870	0.970
60	922.00	2.850	0.950
61	924.00	2.850	0.920
62	926.00	2.780	0.900
63	940.00	2.780	0.880
64	945.00	2.740	0.890
65	950.00	2.720	0.840
66	955.00	2.700	0.820
67	960.00	2.680	0.800
68	970.00	2.650	0.770
69	980.00	2.620	0.740
70	990.00	2.590	0.710
71	1000.00	2.570	0.690
72	1010.00	2.540	0.660
73	1020.00	2.520	0.640
74	1030.00	2.490	0.580
75	1060.00	2.400	0.520
76	1380.00	2.120	0.240

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Waterloo Hydrogeologic 180 Columbia St. W. Waterloo,Ontario,Canada ph.(519)746-1798	Pumping test analysis Recovery method after THEIS & JACOB Unconfined aquifer	Date: 22.07.2003	Page 2
		Project: USAID-OFDA funded	
		Evaluated by: Getachew Alefe	

Pumping Test No. 2	Test conducted on: 19.07.2003
three	Negele rehabilitated hand dug well
Discharge 4.72 l/s	Distance from the pumping well 21.600 m
Static water level: 1.880 m below datum	Pumping test duration: 900.00 min

	Time from end of pumping [min]	Water level [m]	Residual drawdown [m]	Corrected drawdown [m]
1	1.00	2.930	1.050	0.866
2	2.00	2.930	1.050	0.866
3	3.00	2.930	1.050	0.866
4	4.00	2.920	1.040	0.860
5	5.00	2.910	1.030	0.853
6	6.00	2.910	1.030	0.853
7	7.00	2.900	1.020	0.847
8	8.00	2.900	1.020	0.847
9	9.00	2.900	1.020	0.847
10	10.00	2.890	1.010	0.840
11	12.00	2.880	1.000	0.833
12	14.00	2.880	1.000	0.833
13	16.00	2.870	0.990	0.827
14	18.00	2.860	0.980	0.820
15	20.00	2.850	0.970	0.813
16	25.00	2.830	0.950	0.800
17	30.00	2.800	0.920	0.779
18	35.00	2.780	0.900	0.765
19	40.00	2.760	0.880	0.751
20	45.00	2.740	0.860	0.737
21	50.00	2.720	0.840	0.722
22	55.00	2.700	0.820	0.708
23	60.00	2.680	0.800	0.693
24	70.00	2.650	0.770	0.671
25	80.00	2.620	0.740	0.649
26	90.00	2.590	0.710	0.626
27	100.00	2.570	0.690	0.611
28	110.00	2.540	0.660	0.587
29	120.00	2.520	0.640	0.572
30	150.00	2.460	0.580	0.524
31	180.00	2.400	0.520	0.475
32	480.00	2.120	0.240	0.230

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6.3 Quality of the water.

Water sample had taken from the well in the end periods of the pumping test. The sample tested for some chemical constituents and physical parameters at the site level. Physically the sampled water is colorless, odorless and taste nor saline. Moreover; the following values are obtained after examining the water at the field level.

- Conductivity 1366 S/cm
- Temperature 22.6^0 c
- Ph 7
- Total Hardness 356ppm
- Chloride 125 mg/lit
- Nitrate 2.5 mg/lit
- Nitrite 0.05 mg/lit
- Ammonium nill

From the examined constituents no parameter is exceeding the WHO guide line for drinking water quality. However, because of the little hardness of the water it may affect the community during cleaning by taking more detergent.

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7- Final remarks and conclusion.

Water plays vital roll in the development endeavors of mankind and the shortage of water affects directly or indirectly the livelihoods of communities. The shortage of potable water supply is also affecting the residents of Negele town, since the town water supply source mainly relay on the surface water catchments system by earth dam, which accumulating the run off in the rainy season. This makes the town water supply system to be very susceptible for shortage of water in case of drought and/or for prolonged dry season.

Moreover, due to the age and the original construction work makes inefficient the accumulation of water into the dam during rainy season. As result, shortage of water during dry season is becoming common phenomenon for the residents of Negele.

To coup up the problem, it was thought to be helpful to use the water that escaping through the dam by seepage and it possibly by rehabilitation of the existing hand dug wells located along dawn stream side of the dam. The preliminary study work has been done jointly by COOPI and the then BZWMERDD. After, COOPI implemented the project by the fund granted from USAID-OFDA.

The main frame work of the project lay on the rehabilitation of the existing five hand dug wells and establishing a line connection between the wells and the town water supply treatment plant. For this: Five abandoned wells rehabilitated, 1625m long pipe line laid , motor and pump house newly constructed, electric power line re-set work done and the necessary Booster as well as submersible pumps are installed.

The civil construction works as well a pump installation works had been carried out in very careful manner in order to make longer the life span of the scheme, and the scheme constructed in a way that easy for maintenance and service. Over all it 100% fulfill the performance required during project origination.

The out put of the project is expected to address the water shortage problem since it is possible to produce more than 400m^3 of water per day. It expected to sustain around 7500 residents and it also expect to energize any other activities related with the alleviation of the problems' of the town residents.

Although the potential of the aquifer in the area is very high, it is very recommendable to notice carefully before designing and implementation of any additional ground water exploitation interventions in the area: however, the well test data included in this report can be used as the base for any other expansion and upgrading of the scheme.

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